Anne Arundel County
Public Schools

Support provided by NASA Goddard Education Programs

Earth Space Systems Science

Unit 5: The Biosphere

Earth/Space Systems Science
Unit IV: The Biosphere

The Coordinator of Science, Anne Arundel County Public Schools, Maryland would appreciate notification if you plan to use all or any of this educational product at rslutskin@aacps.org

Earth/Space Systems Science
Unit IV: The Biosphere

Description

The biosphere refers to the living and dead organic material on planet Earth. This unit helps students to begin to examine the interactions of the biosphere with the other spheres: the atmosphere, the hydrosphere, the geosphere, and the space sphere.

There is continuous cycling and rearrangement of atoms that make up the matter of the universe. This matter is made of both living and nonliving material. Through chemical reactions, different compounds and substances are formed and energy is either used or released.

Of importance in understanding the biosphere are topics such as the global water and energy cycle, climate variability and its impact, and biogeochemistry (in particular the global carbon cycle). Also important are the dynamics of natural ecosystems and human impact on such systems (such as vegetation, soils, and atmospheric interactions), ocean biology, and computer and numerical modeling of these complicated systems.

Applications stemming from the understanding of the biosphere and its interrelationships within the earth-space system include aquaculture and agriculture, use of natural resources, implications of natural hazards, environmental quality, environment and human health, and urban infrastructure.

Key question for this unit is:

How are global conditions affected when natural and human-induced change alter the transfer of energy and matter?

Key Concepts

- The earth is a system containing essentially a fixed amount of each stable chemical atom or element. Each element can exist in several different chemical reservoirs. Each element on earth moves among reservoirs in the solid earth, oceans, atmosphere and organisms as part of geochemical cycles. (NSES p.189)

- Movement of matter between reservoirs is driven by Earth's internal and external sources of energy. These movements are often accompanied by a change in physical and chemical properties of the matter. Carbon, for example, occurs in carbonate rocks such as limestone, in the atmosphere as dissolved carbon dioxide, and in all organisms as complex molecules that control the chemistry of life. (NSES, p. 189)

- Evidence for one-celled forms of life- the bacteria-extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of the Earth's atmosphere, which did not originally contain oxygen. (NSES, p. 190)

- The amount of life any life can support is limited by the available energy, water, oxygen, and minerals, and by the availability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land. (AAAS, p. 121)

- Natural ecosystems provide an array of basic processes that affect humans. Those processes include maintenance of the quality of the atmosphere, generation of soils, control of the hydrologic cycle, disposal of wastes, and recycling of nutrients. Humans are changing many of these basic processes and the change may be detrimental.

CONTENT OUTLINE

THE BIOSPHERE

I. Climate type and distribution
   A. Temperature
   B. Precipitation
   C. Cloud cover
   D. Sea level
      1. glaciers
      2. sea ice
      3. coastlines
         a) emergent
         b) submergent
   E. Biomes
      1. location
      2. distribution

II. Pollutants
   A. Tropospheric ozone
      1. concentration
      2. distribution
   B. Acid rain
   C. Greenhouse gases

III. Ocean-atmosphere-land interactions
   A. El Niño, La Niña

Earth/Space Systems Science
Unit IV: The Biosphere

LESSON	TITLE	BLOCKS
1	CLIMATE TYPES AND DISTRIBUTIONS	TWO
2	BIOMES	TWO
3	CLIMATE VARIABILITY	ONE
4	HUMAN IMPACT - EL NIÑO AND LA NIÑA	ONE
5	GREENHOUSE GASES AND CLIMATE CHANGE	ONE
6	COASTLINES AND CHANGES IN SEA LEVEL	TWO
7	GLOBAL WARMING AND POLLUTION – ANALYZING THE ISSUES	ONE
8	POLLUTION IN THE TROPOSPHERE	TWO
9	MASS EXTINCTION	ONE
APPROXIMATE NUMBER OF TIME BLOCKS		13

Earth/Space Systems Science
Unit IV: The Biosphere

Materials per Lab Group

Air pump: bicycle pump or sports ball pump
Balloons: 1 per lab group
Beaker, 250 mL
Blank climographs
Bromothymol blue
Calculator
Chart paper
Climate Data Table
Corn starch
Cotton balls, 3
County map (optional)
Deck of cards
Distilled water
Dropper bottle of ammonia or other base
Duct tape
Empty balloons 8 or 10-inch diameter, 2
Filter paper
Flour
Funnel
Graph paper
Graphs greenhouse gases & human activities

Hot pad or mitt
Hot plate
Manila folder
Map of Antarctica
Map of Greenland
Markers
Mass Extinction graph
Overhead pen
Paint brush, small
Pair of heat resistant oven mitts
Pan
Poster paper
Potassium iodide
Pyrex plate
Spray bottle
Stirring rod, Glass
Straws, 3
Tape, masking
Test tube rack
Transparency

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 1: CLIMATE TYPES AND DISTRIBUTIONS

Estimated Time: Two blocks

Indicator(s): Core Learning Goal 1

1.4.1 The student will organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title).

1.5.3 The student will use computers and/or graphing calculators to produce the visual materials (tables, graphs, and spreadsheets) that will be used for communicating results.

1.5.7 The student will use, explain, and/or construct various classification systems.

Indicator(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits: Climate type and distribution (temperature and precipitation.)

Student Outcome(s):

1. The student will be able to classify the climate of an area by analyzing data and using the Koppen classification system.
2. The student will be able to describe factors that influence climate by reading a technical selection and completing a graphic organizer.

Brief Description:

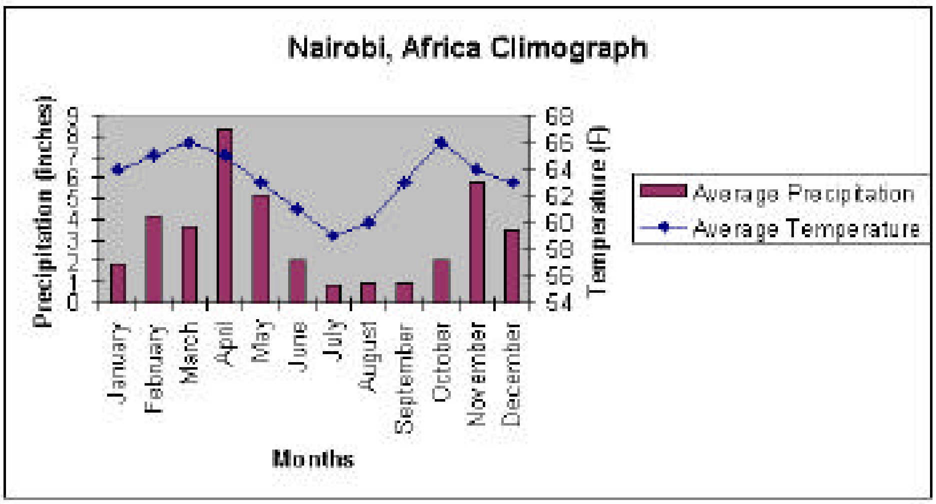
Students create and analyze climographs to classify climates using the Koppen classification system.

Background knowledge / teacher notes:

· A climograph summarizes the climate of a location on a single diagram. A climograph consists of the following elements:

- Months of the year are located along the bottom.
- Vertical axes are used to plot temperature (the left-hand scale) and precipitation (the right-hand scale). Average monthly temperatures are plotted by placing a dot in the center of the respective column of each month; the dots are then connected to form a line graph.
- Average monthly precipitation is charted by a vertical bar in the respective month's column corresponding in length to the amount of precipitation as measured along the right-hand scale.

Example:



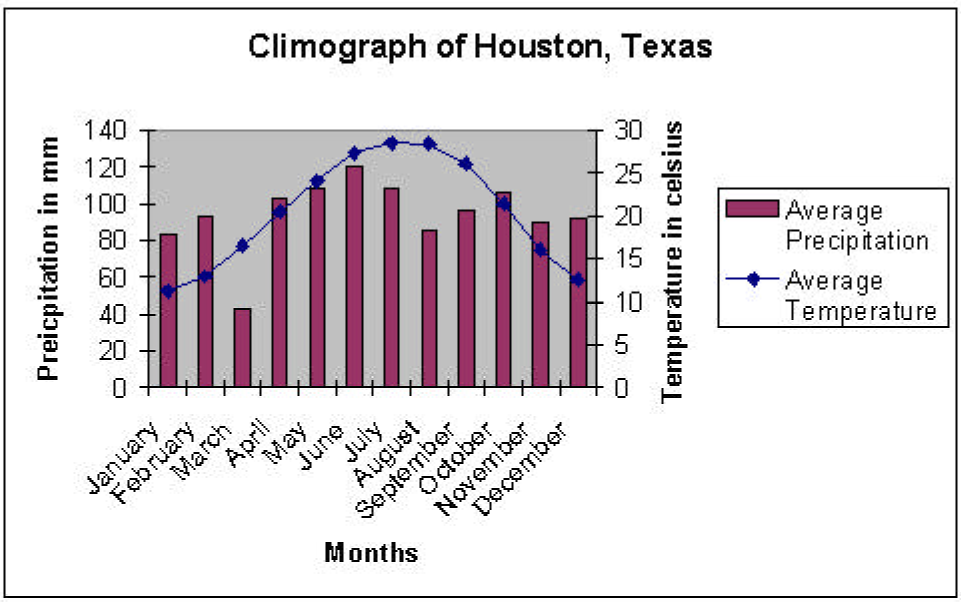
Observations to make about climate

- Low-latitude locations have warmer temperatures and smaller annual temperature ranges than high-latitude locations.
- Continental locations tend to have much larger annual temperature ranges than coastal locations at the same latitude.
- Colder locations tend to have less precipitation than warm locations because warm air can hold more moisture than cold air.
- The basic control on temperature is latitude, while the effect of a continental or maritime location is an important secondary control.

Spreadsheets and graphs produced by students should look like the following:

Houston, Texas

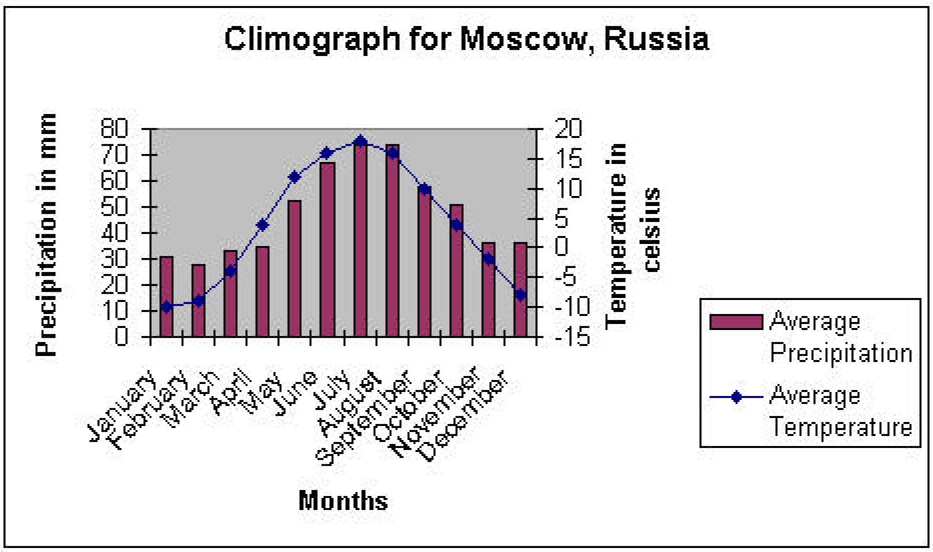
Month	Average Precipitation	Average Temperature
January	82.8	11.2
February	93.6	12.9
March	42.7	16.5
April	102.8	20.5
May	108.1	24.1
June	120.7	27.3
July	108.8	28.5
August	85.5	28.4
September	96.6	26.1
October	105.9	21.4
November	90	16
December	91.9	12.5



Moscow, Russia

Month	Average Precipitation	Average Temperature
January	31	-10
February	28	-9

March	33	-4
April	35	4
May	52	12
June	67	16
July	74	18
August	74	16
September	58	10
October	51	4
November	36	-2
December	36	-2



From NASA Explores. *Star City Teacher Page.*

Available: http://nasaexplores.com/lessons/01-082/9-12_2-t.html

Lesson Description:

ENGAGE	Think-Pair-Share What is the difference between weather and climate? *Weather is the condition at any given moment in a day. Climate is the annual average of daily weather conditions or long-term weather patterns.* Brainstorm factors that influence climate. *Rainfall, temperature, snow, cloud cover*

	As a class, combine factors into two major categories: temperature and precipitation. Read to be informed about the difference between climate and weather. Glencoe McGraw-Hill. (2002). Glencoe Earth Science: Geology, the Environment and the Universe. pp. 359-361. Or. Prentice-Hall. (2002). Lutgens & Tarbuck Foundations of Earth Science. p. 272. Or other similar text passages. Discussion: How much weather data is needed before the climate can be described? *Weather information is collected over a long period of time, usually at least 30 years. Using this information, norms are established.*
EXPLORE	Have students form groups of two. Assign each group a city from the list provided at the following website: South Shore Educational Collaborative. *Climate Data Table.* Available: http://www.ssec.org/idis/gates/States/climdat.htm Teacher Note: Students may collect their own precipitation and temperature data by visiting Go to Weather.com. *The Weather Channel. The Local Forecast.* Available: http://www.weather.com/weather/local/21401?lswe=21401&lwsa=WeatherLocalUndeclared

	Materials per pair: Climate Data Table Directions: 1. What is the name of the city you were assigned? 2. Design a data table to record the temperature and precipitation data for your city. 3. Using the Climate Data Table, record the monthly temperature and precipitation data for your city. 4. Graph the precipitation data. Adaptive Strategy: Discuss what type of graph should be used with this data. *Bar graph.* Allow students to graph the data using a graphing calculator or NCES. *Create a Graph.* Available: http://nces.ed.gov/nceskids/graphing/ 5. Or if you are collecting your own data, follow steps 1 -7. Directions: 1. Go to Weather.com. *The Weather Channel. The Local Forecast.* Available: http://www.weather.com/weather/local/21401?lswe=21401&lwsa=WeatherLocalUndeclared 2. At the top of the screen, next to Local Forecast, type in the zipcode of your city. 3. This will give you the weather forecast for your local area. 4. Scan down the screen and locate the Averages and Record button. 5. Click on this button. 6. Record the monthly temperature and precipitation data for your city. 7. Graph the precipitation data. Adaptive Strategy: Discuss what type of graph should be used

	with this data. *Bar graph.* Allow students to graph the data using a graphing calculator or NCES. *Create a Graph.* Available: http://nces.ed.gov/nceskids/graphing/
EXPLAIN	***Journal Write:*** 8. How many months had an average temperature of more than 65 degrees? 9. How many months had an average temperature of more than 50 degrees? 10. How many months had 0.5 inches of precipitation or less? 11. What was the average temperature of the warmest month?
EXTEND	Koppen Climate Classification System Directions: When you have completed this activity, you will have classified your climate as a series of letters. 1. Use the temperature and precipitation data you collect on your city to classify your climate. ***Journal Write:*** Record all the letters here____________________. Be sure to maintain the correct case for the letters. 2. A. If the total precipitation is less than or equal to 14.0 inches, but greater than 10.0 inches, record "BS." B. If the total precipitation was 10.0 inches or less, record a "BW." 3. A. If all twelve of the months had an average temperature of more than 65 degrees, add an "A." B. If 8 months or more with an average temperature over 50, but the coolest month was under 65, add a "C." C. If 4 to 7 months had an average temperature over 50, add a "D."

	D. If 1 to 3 months had an average temperature over 50, add an "E." 4. A. If one month or none of the months had less than 0.5 inches of precipitation, record an "r." B. If all the months had greater than or equal to .5 inches of precipitation, record a "d." 5. A. If the average temperature of the warmest month was 72 degrees or higher, record "a." B. If the average temperature of the warmest month was less than 72 degrees record a "b". 6. Examine the precipitation graph. A. If the bars are of similar heights, record an " f " B. If there is a bulge in the center of the graph, record a "w" (winter dry). C. If there is a dip in the center of the graph, record "a" (summer dry). 7. Examine a world map to determine the following: A. If your city is located near an ocean or major lake, record a "o." B. If your city is NOT located near an ocean or major lake, record a "c." Adaptive Strategy: Choose a city and model how to classify the climate using the Koppen classification system. Find out what these letters mean by reading about the Koppen Climate Classification System. GVg. *Koppen Climate Classification.* Available: http://www.geofictie.nl/ctkoppen.htm Or Glencoe McGraw-Hill. (2002). Glencoe Earth Science: Geology,

	the Environment and the Universe. pp. 364-366. Or other similar text passages. ***Journal Write:*** 1. Create a graphic organizer to record the five main divisions of the Koppen classification system. 2. In the graphic organizer record the major characteristics of each division. Teacher Note: Students should know the characteristics of the five major divisions and should be able to analyze climographs. Students do not have to know the characteristics of subclimates. Students create climographs and analyze the climate of two different areas. Climographs In 1998, when the first module of the new International Space Station launched from the Baikonur cosmodrome in Kazakhstan, world attention once again riveted towards space, this time to witness a new beginning. Unlike the first era of space flight that began with Yuri Gagarin's flight in 1961, characterized by Cold War competition and “a space race,” this new era of space flight is heralded as the age of the “International Astronautics and Cosmonautics.” This bond requires American astronauts to travel to Russia and cosmonauts to travel to the United States. Astronauts prepare for space missions at JSC in Houston, Texas and at the Yuri Gagarin Cosmonaut Training Center in Star City, Russia. Star City is located 1 hour (driving time) from Moscow. The climatic conditions are very different for astronauts when they travel to Russia. If you were traveling to Russia, you would need to know what type of clothing items to pack. In order to

	determine this, you will construct a climograph for Houston, Texas and one for Moscow, Russia. By comparing the two climographs, you can determine which months are the best for travel and how to pack How to make a climograph: · A climograph summarizes the climate of a location on a single diagram. A climograph consists of the following elements: · Months of the year are located along the bottom. · Vertical axes are used to plot temperature (the left-hand scale) and precipitation (the right-hand scale). · Average monthly temperatures are plotted by placing a dot in the center of the respective column of each month; the dots are then connected to form a line graph. · Average monthly precipitation is charted by a vertical bar in the respective month's column corresponding in length to the amount of precipitation as measured along the right-hand scale. Adaptive Strategy: Show students how to interpret climographs. Climographs for a variety of cities are available at Florida State University. *GEOG 3200 Climograph Practice.* Available: http://mailer.fsu.edu/~jstallin/dir/course/home/Geo3200/climographs/Climographs.html Technical Connection: Now, construct a climograph using Excel. Directions for using Excel to make a climograph: 1. Open Microsoft Excel. Adaptive Strategy: Point out that letters mark the Excel matrix columns and numbers mark the rows. 2. Click on the cell at C-3.

	3. Type in "Month," press return. 4. The cell now highlighted should be C-4. Type the word "January," press return. 5. Type the word "February" in the next cell (C-5), press return. 6. Enter all of the months. When you are finished, cell C-15 should read "December." 7. Go to cell D-3 and type in the words "Average Precipitation," press return. 8. Resize the columns so that the entire title is shown. <u>Adaptive Strategy:</u> Demonstrate how to resize the columns. Resize the columns by positioning the mouse arrow on the line where columns D and E touch. This should transform the arrow into an icon resembling a plus sign with arrows on the right and left lines. Left click on the mouse, and drag to the right. This widens the column, allowing "Average Precipitation" to be completely contained within the cell. 9. In the cell directly to the right of the each month, enter the average precipitation for each month. 10. When all the precipitation data are entered, click on the cell at E-3, and type "Average Temperature." Resize the column if needed. 11. Enter the average temperature for each month, just like you did for the average precipitation. 12. This is your data table. This table will be used to construct your climograph. 13. Click and hold on the cell at C-3 that reads "months" and drag down and to the right until the entire table is selected. (You should drag to cell E-15.) <u>Adaptive Strategy</u>: Model how to select a section of the table. 14. On the top row of icons to the right, click on the Chart

Wizard.

15. A Chart Wizard dialog box will open. Notice that you are in "Step 1 of 4."
16. Click on the tab near the top that reads "Custom Types."
17. Under "Chart Type," scroll down until you see the "Line – Column on 2 Axes" option, and click on it.
18. Now, click on the "Next " button at the bottom of the screen to move on to Step 2.
19. You should see, the Data Range equals the sheet you were working on (Sheet1) and the cells you selected ($C$3:$E$15).
20. Click on the "Next" button at the bottom. This brings up Step 3, which focuses on different Chart Options.
21. Type in a title for your graph. Press the tab key to move to the next field. *DO NOT hit the return key. If you do you will be taken to the next step.*
22. Under the "Category (X) Axis," enter the word "Months," and press tab.
23. Under the "Value (Y) Axis," enter the words "Precipitation in mm," and press tab twice.
24. Under the "Second Value (Y) Axis," enter the words "Temperature in Celsius," and press tab.
25. Near the top center of the dialog box, click on the tab that reads "Legend." Using the placement box, decide where you want your legend to be displayed. When you have made your choice, press the "Next >" button.
26. On the final dialog box, click the button next to "As new sheet," and press "Finish" button.
27. To change part of the climograph, double click on a part and open a format dialog box. When you are satisfied with the way the graph looks, press the (OK) button at the bottom of

	the box. 28. Save your work as instructed by your teacher. ***Journal Write:*** 29. How do you think the latitude affects the climate? 30. Based on your climograph, which is the coldest month of the year in Moscow? 31. During which months of the year in Moscow is there more than 60 millimeters of precipitation? 32. In which month do you think it would be best to visit Moscow, if you like mild, dry weather? 33. How does the temperature and precipitation compare between Moscow and Houston? From NasaExplores. *Star City*. Available: http://nasaexplores.com/lessons/01-082/9-12_2.html Teacher Note: Climographs are done using either metric or English units. Use the units that match your data. G/T Connection: Make a climograph of Anne Arundel County. Weather.com. *The Weather Channel. The Local Forecast.* Available: http://www.weather.com/weather/local/21401?lswe=21401&lwsa=WeatherLocalUndeclared Temperature and precipitation data from many places in the world can be found at World Climate. *World Climate.* Available: http://www.worldclimate.com/ Discussion:

	1. What factors influence climate? 2. How do these factors influence climate? Read to be informed about factors influence climate. Canada's Digital Collection. *Factors that influence climate.* Available: http://collections.ic.gc.ca/abnature/environmental/climatefactors.htm Or tgp. The geography portal. *Online Tutorial - Weather and Climate* Available: http://www.kesgrave.suffolk.sch.uk/Curric/geog/climterm.html Or EOS.NASA. *Clouds and Radiation.* Available: http://earthobservatory.nasa.gov/Library/Clouds/ ***Journal Write:*** 1. Create a graphic organizer on factors that influence climate. 2. Describe how each of these factors influence climate.
EVALUATE	***Journal Write***: 1. Explain how Koppen classification system is used to identify climates. 2. Describe factors that influence climate.

Materials per lab group:

- Climate Data Table

Koppen Climate Classification System

Directions:

When you have completed this activity, you will have classified your climate as a series of letters.

1. Use the temperature and precipitation data you collect on your city to classify your climate.

Journal Write:

Record all the letters here____________________. Be sure to maintain the correct case for the letters.

2. A. If the total precipitation is less than or equal to 14.0 inches, but greater than 10.0 inches, record "BS."

   B. If the total precipitation was 10.0 inches or less, record a "BW."

3. A. If all twelve of the months had an average temperature of more than 65 degrees, add an "A."

   B. If 8 months or more with an average temperature over 50, but the coolest month was under 65, add a "C."

   C. If 4 to 7 months had an average temperature over 50, add a "D."

   D. If 1 to 3 months had an average temperature over 50, add an "E."

4. A. If one month or none of the months had less than 0.5 inches of precipitation, record an "r."

   B. If all the months had greater than or equal to .5 inches of precipitation, record a "d."

5. A. If the average temperature of the warmest month was 72 degrees or higher, record "a."

   B. If the average temperature of the warmest month was less than 72 degrees record a "b".

6. Examine the precipitation graph.

   A. If the bars are of similar heights, record an " f "

   B. If there is a bulge in the center of the graph, record a "w" (winter dry).

   C. If there is a dip in the center of the graph, record "a" (summer dry).

7. Examine a world map to determine the following:

   A. If your city is located near an ocean or major lake, record a "o."

   B. If your city is NOT located near an ocean or major lake, record a "c."

Earth/Space Systems Science
Unit IV: The Biosphere

Climographs

Background information:

In 1998, when the first module of the new International Space Station launched from the Baikonur cosmodrome in Kazakhstan, world attention once again riveted towards space, this time to witness a new beginning. Unlike the first era of space flight that began with Yuri Gagarin's flight in 1961, characterized by Cold War competition and “a space race,” this new era of space flight is heralded as the age of the “International Astronautics and Cosmonautics.”

This bond requires American astronauts to travel to Russia and cosmonauts to travel to the United States. Astronauts prepare for space missions at JSC in Houston, Texas and at the Yuri Gagarin Cosmonaut Training Center in Star City, Russia. Star City is located 1 hour (driving time) from Moscow. The climatic conditions are very different for astronauts when they travel to Russia. If you were traveling to Russia, you would need to know what type of clothing items to pack. In order to determine this, you will construct a climograph for Houston, Texas and one for Moscow, Russia. By comparing the two climographs, you can determine which months are the best for travel and how to pack

How to make a climograph:

- A climograph summarizes the climate of a location on a single diagram. A climograph consists of the following elements:
- Months of the year are located along the bottom.
- Vertical axes are used to plot temperature (the left-hand scale) and precipitation (the right-hand scale).
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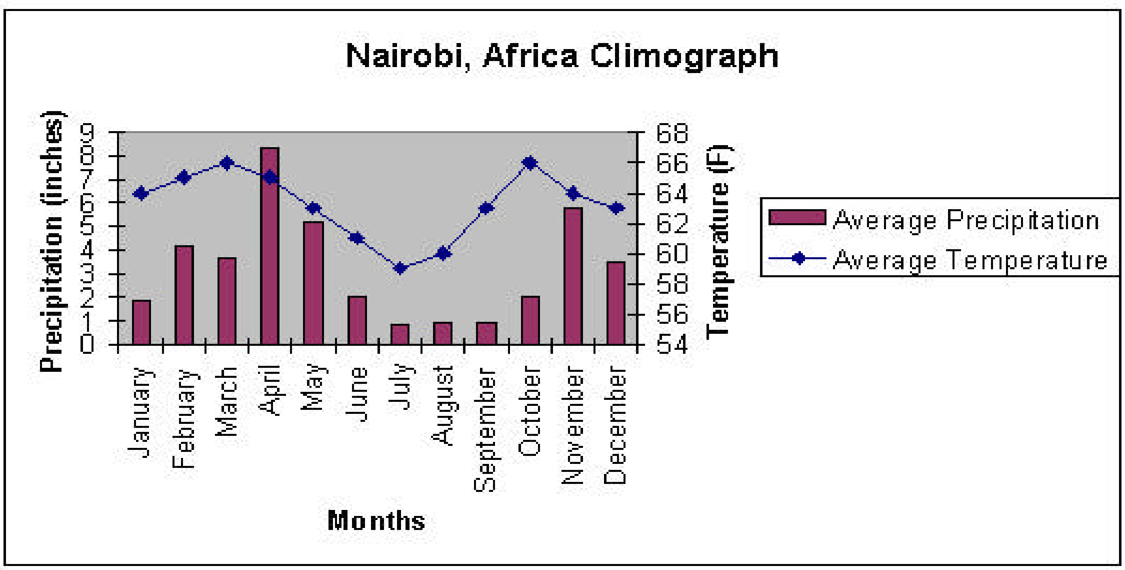
Example:



Houston, Texas—Located at 29.97°N, 95.35°W.

<u>Average Temperature</u>

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°C	11.2	12.9	16.5	20.5	24.1	27.3	28.5	28.4	26.1	21.4	16.0	12.5

°F	52.2	55.2	61.7	68.9	75.4	81.1	83.3	83.1	79.0	70.5	60.8	54.5

Source: derived from GHCN 2 Beta

Average Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
mm	82.8	93.6	42.7	102.8	108.1	120.7	108.8	85.5	96.6	105.9	90.0	91.9
inches	3.3	3.7	1.7	4.0	4.3	4.8	4.3	3.4	3.8	4.2	3.5	3.6

Source: derived from NCDC Cooperative Stations.

Moscow, Russia—*Located at 55°N, 37°E*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temperature (°C)	-10	-9	-4	+4	12	16	18	16	10	4	-2	-8
Average Precipitation (mm)	31	28	33	35	52	67	74	74	58	51	36	36

Now, construct a climograph using Excel.

Directions for using Excel to make a climograph:

1. Open Microsoft Excel.
2. Click on the cell at C-3.
3. Type in "Month," press return.
4. The cell now highlighted should be C-4. Type the word "January," press return.
5. Type the word "February" in the next cell (C-5), press return.
6. Enter all of the months. When you are finished, cell C-15 should read "December."
7. Go to cell D-3 and type in the words "Average Precipitation," press return.
8. Resize the columns so that the entire title is shown.
9. In the cell directly to the right of the each month, enter the average precipitation for each month.
10. When all the precipitation data are entered, click on the cell at E-3, and type "Average Temperature." Resize the column if needed.
11. Enter the average temperature for each month, just like you did for the average precipitation.
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26. On the final dialog box, click the button next to "As new sheet," and press "Finish" button.
27. To change part of the climograph, double click on a part and open a format dialog box. When you are satisfied with the way the graph looks, press the (OK) button at the bottom of the box.
28. Save your work as instructed by your teacher.

Journal Write:

29. How do you think the latitude affects the climate?
30. Based on your climograph, which is the coldest month of the year in Moscow?

31. During which months of the year in Moscow is there more than 60 millimeters of precipitation?
32. In which month do you think it would be best to visit Moscow, if you like mild, dry weather?
33. How does the temperature and precipitation compare between Moscow and Houston?

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Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 2: BIOMES

Estimated Time: Two blocks

Indicator(s): Core Learning Goal 1

1.4.1 The student will organize data appropriately using techniques such as tables, graphs, and webs (for graphs: axes labeled with appropriate quantities, appropriate units on axes, axes labeled with appropriate intervals, independent and dependent variables on correct axes, appropriate title).

1.5.4 The student will use tables, graphs, and displays to support arguments and claims in both written and oral communications.

1.5.7 The student will use, explain, and/or construct various classification systems.

1.5.8 The student will describe similarities and differences when explaining concepts and/or principles.

Indicator(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter.
Assessment limits (at least) –Sea level, glaciers and sea ice, biome location and distribution

Student Outcome(s):

The student will be able to analyze the relationship between climate and the location and distribution of biomes by reading a technical selection and creating and interpreting climographs.

Brief Description:

In this lesson, students explore the characteristics of biomes and the relationship between climate and the location and distribution of biomes.

Background knowledge / teacher notes:

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson Description:

ENGAGE	Show pictures of different biomes: rainforest, grassland, desert, forest, tundra… Salem State College. *Biome Dome.* Available: http://www.dgl.salemstate.edu/Profs/Young/STUDENTS/biodome/biomedom.htm Discussion: 1. What is this a picture of? *rainforest, grassland, desert, forest, tundra…* 2. What do all these pictures have in common? 3. What term is use to classify these ecosystems? *Biome* 4. What are biomes? *Biomes are the various regions that can be distinguished by their climate, fauna and flora.* View the world map of biomes Pandora. *WorldBiomes.com Map.* Available: http://www.worldbiomes.com/biomes_map.htm 5. Predict how climate might influence the location of biomes.
EXPLORE	Assign each group a biome to investigate. As a class, develop a graphic organizer to record information about each biome. Suggested sites to find information on biomes. Wheeling Jesuit University/NASA Classroom of the Future. *Earth Floor: Biomes.* Available: http://www.cotf.edu/ete/modules/msese/earthsysflr/biomes.html University of Richmond. *Learn About Biomes.* Available:

	http://oncampus.richmond.edu/academics/as/education/projects/webunits/biomes/biomes.html Pandora. *WorldBiomes.com* Available: http://www.worldbiomes.com Click on the names of the biomes at the top and bottom of the page. Charter College of Education, California State University, Los Angeles.*World Builders: Introduction to Biomes.* Available: http://curriculum.calstatela.edu/courses/builders/lessons/less/biomes/introbiomes.html
EXPLAIN	Using an overhead or poster, each group presents information about their biome to the class. ***Journal Write:*** Record information about each biome in the graphic organizer.
EXTEND	Working in small groups, students investigate the relationship among rainfall, temperature and the distribution of biomes. (See resources). Based on *Temperature, Rainfall, and Biome Distribution Lab.* Available: http://www.geocities.com/Athens/Parthenon/1020/biome.html **Biome Distribution** Materials: Blank climographs **Part One:** 1. Create a climograph for each of the locations below by graphing the precipitation and temperature data. 2. Identify the biome represented in the climograph. Adaptive Strategy: Model how to create a climograph. Temperature readings are measured on the right side of the climograph. Precipitation

	measurements are on the left side. Use line a graph for temperature and a bar graph for precipitation. 3. Combined with the six climographs below, you now have ten climographs representing ten different biomes found worldwide. ***Journal Write:*** Lawrence, Kansas and Nashville, Tennessee occupy similar latitudes. Why is one a grassland and the other a forest biome? **Part Two** 1. Graph the data for the unknown biomes assigned to your group. ***Journal Write:*** 2. Look at the climographs you created for the unknown biomes. Using the climographs from part one as a comparison, identify each of the unknown biomes. 3. Which biomes are located in the southern hemisphere? Use evidence from the climographs to support your answer. **Part Three** 1. Create climographs for unknown locations assigned to your group. ***Journal Write:*** 2. All six climographs represent the same biome. Using the information in the climographs, what type of biome is represented? 3. A-C occupies similar latitudes, but differing altitudes; D-F occupy differing latitudes. Using your knowledge of biomes and climographs, predict the altitude and/or latitude for each biome assigned to your group. 4. Support your predictions using data from the climographs and information about biomes. Adaptive Strategy: Do a think aloud and discuss what characteristics on the climographs you examine for altitudinal and latitudinal analysis. Possible characteristics: areas of high rainfall-northern or southern latitudes? Which has warmer temperatures- northern or southern

	latitudes? High or low altitudes? Materials: map showing the location and distribution of biomes. Animals of the Rainforest. *Tropical Rainforest.* Available: http://www.animalsoftherainforest.org/map.htm Pandora. *WorldBiomes.com Map.* Available: http://www.worldbiomes.com/biomes_map.htm 5. Using the information from the climographs representing the ten basic biomes, identify the location and distribution of biomes on the world map. Adaptive Strategy: Assign each group one biome to map. G/T Connection: Using the information from the climographs representing the ten basic biomes, generate a world map illustrating the location and distribution of biomes. Materials: world map, colored pencils
EVALUATE	***Journal Write:*** Describe the relationship between climate and the location and distribution of biomes. Use evidence from the investigation and technical reading to support your answer.

Materials per lab group:

- Blank climographs

Earth/Space Systems Science
Unit IV: The Biosphere

Biome Distribution

Part One:

1. Create a climograph for each of the locations below by graphing the precipitation and temperature data.
2. Identify the biome represented in the climograph.

Precipitation and Temperature Data

Cuiaba, Brazil: Tropical Deciduous Forest

	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
P:	24.9	21.1	21.1	10.2	5.3	0.8	0.5	2.8	5.1	11.4	15	20.6
T:	27.2	27.2	27.2	26.6	25.6	23.9	24.4	25.6	27.8	27.8	27.8	27.2

Santa Monica, California: Chaparral

	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
P:	8.9	7.6	7.4	1.3	1.3	0	0	0	0.3	1.5	3.5	5.8
T:	11.7	11.7	12.8	14.4	15.6	17.2	18.9	18.3	18.3	16.7	14.4	12.8

Moshi, Tanganyika: Tropical Grassland

	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
P:	3.6	6.1	9.2	40.1	30.2	5.1	5.1	2.5	2	3	8.1	6.4
T:	23.3	23.2	22.2	21.1	19.8	18.4	17.9	18.4	19.8	21.4	22	22.4

Aden, Aden: Tropical Desert

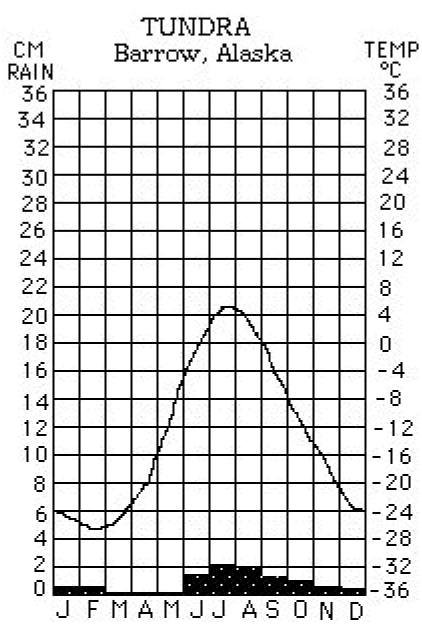
	J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**

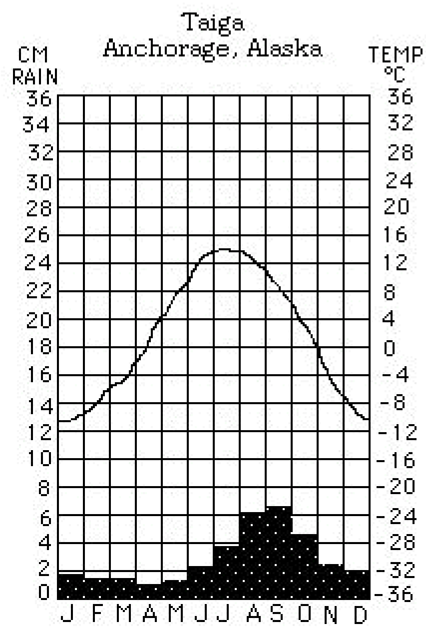
P:	0.8	0.5	1.3	0.45	0.3	0.3	0	0.3	0.3	0.3	0.3	0.3
T:	24.6	25.1	26.4	28.5	30.6	31.9	31.1	30.3	31.1	28.8	26.5	25.1

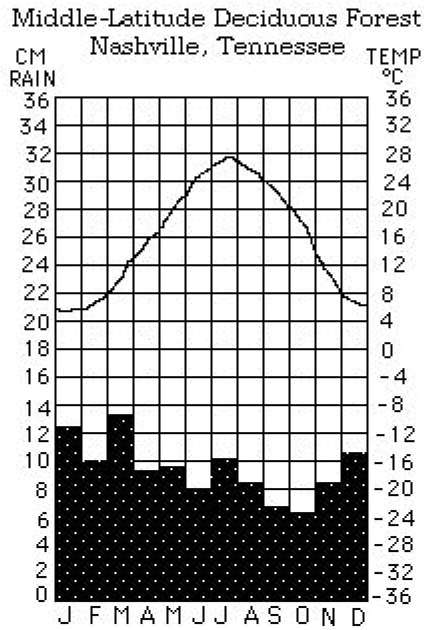
3. Combined with the six climographs below, you now have ten climographs representing ten different biomes found worldwide.

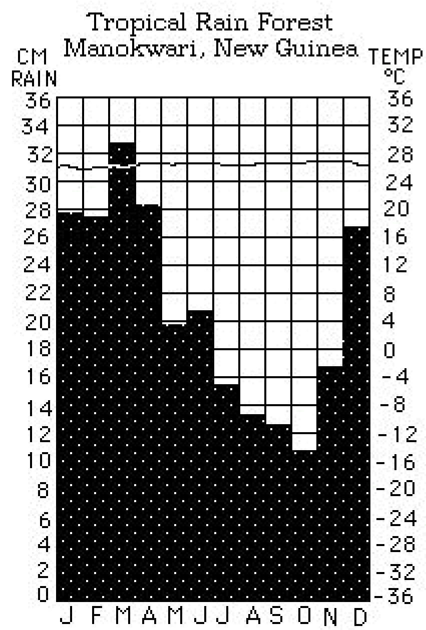
Journal Write:

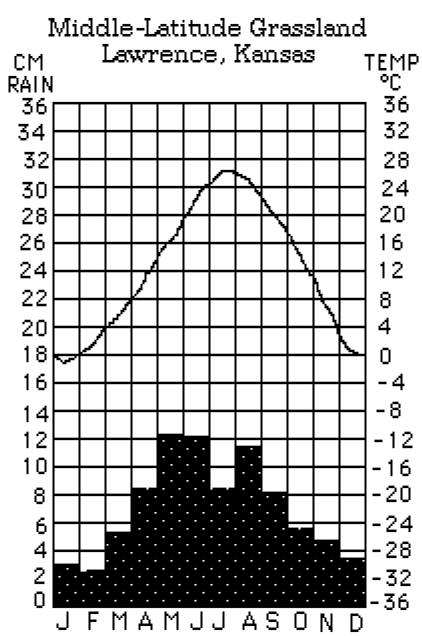
Lawrence, Kansas and Nashville, Tennessee occupy similar latitudes. Why is one a grassland and the other a forest biome?

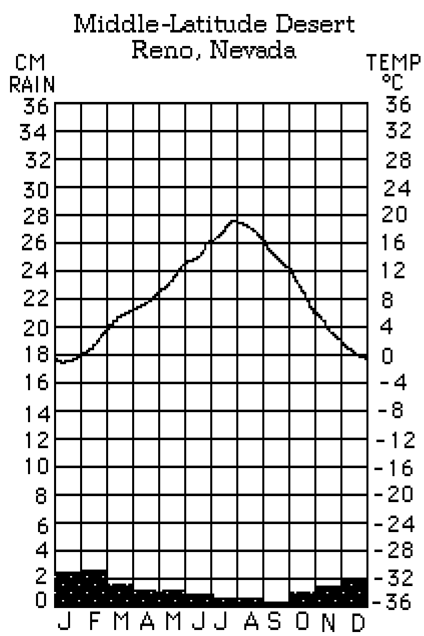












Part Two

1. Graph the data for the unknown biomes assigned to your group.

   A. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	8.1	7.6	8.9	8.4	9.2	9.9	11.2	10.2	7.9	7.9	6.4	7.9
T:	1.1	1.7	6.1	12.2	17.8	22.2	25	23.3	20	13.9	7.8	2.2

B. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	9.1	8.9	8.6	6.6	5.1	2	0.5	0.5	3.6	8.4	10.9	10.4
T:	10.6	11.1	12.2	14.4	15.6	19.4	21.1	21.7	20	16.7	13.9	11.1

C. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	25.8	24.9	31	16.5	25.4	18.8	16.8	11.7	22.1	18.3	21.3	29.2
T:	25.6	25.6	24.4	25	24.4	23.3	23.3	24.4	24.4	25	25.6	25.6

D. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	1	1.3	1	0.3	0	0	0.3	1.3	0.5	0.5	0.8	1
T:	12.8	15	18.3	21.1	25	29.4	32.8	32.2	28.9	22.2	16.1	13.3

E. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	2.3	1.8	2.8	2.8	3.2	5.8	5.3	3	3.6	2.8	4.1	3.3

T:	-3.9	-2.2	1.7	8.9	15	20	22.8	21.7	16.7	11.1	5	-0.6

F. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	0	0	1.5	0.5	8.9	14.7	12.2	8.1	2	1	0.3	0.8
T:	19.4	18.9	18.3	16.1	15	13.3	12.8	13.3	14.4	15	16.7	17.8

G. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	1	1.3	1.8	1.5	1.5	1.3	2.3	2.8	2.8	2.8	2.8	1.3
T:	-22.2	-22.8	-21.1	-14.4	-0.39	1.7	5	5	1.1	-3.9	-10	-17.2

H. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	3.6	4.1	4.6	6.9	8.1	6.9	6.4	6.6	8.9	5.1	5.6	4.6
T:	11.7	12.8	17.2	20.6	23.9	27.2	28.3	28.3	26.1	21.1	16.1	12.2

I. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	5.1	5.6	6.6	5.6	2.8	0.9	2.5	4.1	5.8	5.8	5.1	5.3
T:	23.3	22.2	19.4	15.6	11.7	8.3	8.3	9.4	12.2	15.1	18.9	21.7

J. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	0.3	0.5	1.5	3.6	8.6	9.2	9.4	11.4	10.9	5.3	0.8	0.3
T:	17.2	18.9	21.1	22.8	23.3	22.2	21.1	21.1	20.6	19.4	18.9	17.2

K. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	3.3	2.3	2.8	2.5	4.6	5.6	6.1	8.4	7.4	4.6	2.8	2.8
T:	-20	-18.9	-12.2	-2.2	5.6	12.2	16.1	15	10.6	3.9	-5.6	-15

L. Unknown biome

	J	F	M	A	M	J	J	A	S	O	N	D
P:	1.5	1.3	1.3	1	1.5	0.8	0.3	0.5	0.8	1	0.8	1.5
T:	-0.6	2.2	5	10	13.3	18.3	23.3	22.2	16.1	10.6	4.4	0

Journal Write:

2. Look at the climographs you created for the unknown biomes. Using the climographs from part one as a comparison, identify each of the unknown biomes.
3. Which biomes are located in the southern hemisphere? Use evidence from the climographs to support your answer.

Part Three

1. Create climographs for unknown locations assigned to your group.

Journal Write:

2. All six climographs represent the same biome. Using the information in the climographs, what type of biome is represented?

A. Altitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	-6.7	-5	1.7	9.4	15.6	21.1	23.9	22.2	17.8	11.1	2.8	-3.9
P:	3.8	3.6	5.6	6.6	9.9	11.4	9.4	8.6	10.2	6.4	4.8	3.8

B. Altitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	-4.6	-1.9	2.6	9.9	15.8	21.8	25.7	24.4	18.9	12.2	3.3	-2.2
P:	1.3	1.6	2.8	6.1	9.9	10.3	6.5	5.2	6.1	3	2.1	1.5

C. Altitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	-6.1	-5.6	-1.7	3.3	7.8	12.8	16.7	16.7	11.1	5	-1.1	-5.6
P:	1.3	0.8	2	2.5	3.8	3.1	4.3	3	2.5	2.3	1.3	1.3

D. Latitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	12.2	13.3	17.2	21.1	24.4	27.8	28.9	28.3	26.7	22.8	17.2	13.9
P:	8.6	7.6	7.4	7.9	8.6	10.7	10.2	11.9	14.5	10.9	9.9	9.4

E. Latitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	-5.6	-3.9	2.8	10.6	17.2	22.2	25	23.9	18.9	12.8	3.9	-2.8
P:	1.8	2.3	3.3	7.1	10.4	11.9	10.2	8.1	7.6	5.8	2.8	2.3

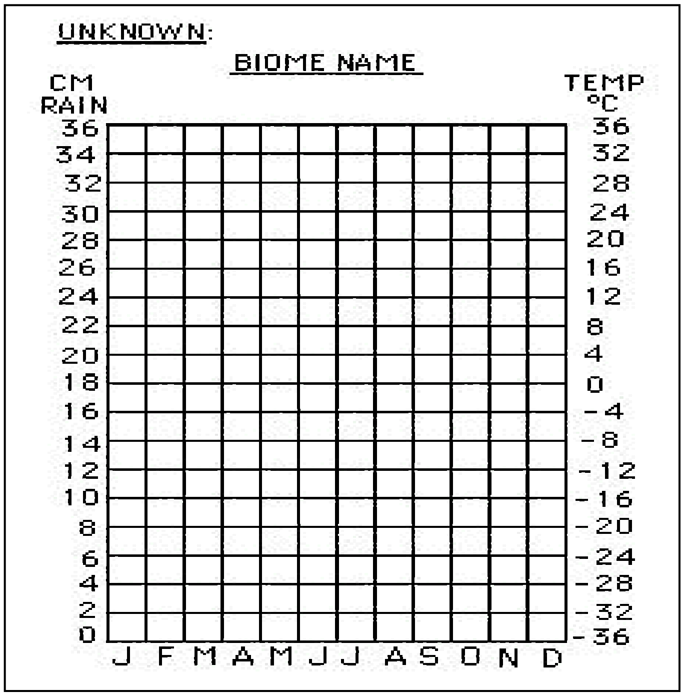
F. Latitudinal Variation

	J	F	M	A	M	J	J	A	S	O	N	D
T:	-20	-17.8	-9.4	3.3	11.1	16.7	18.9	17.8	12.2	5	-6.1	-14.4
P:	2.3	1.8	3.3	3.6	5.1	7.9	7.9	5.6	5.6	3.6	2.8	2.3

Journal Write:

3. A-C occupies similar latitudes, but differing altitudes; D-F occupy differing latitudes. Using your knowledge of biomes and climographs, predict the altitude and/or latitude for each biome assigned to your group.
4. Support your predictions using data from the climographs and information about biomes.

Modified from Michael Topham. *Temperature, Rainfall and Biome Distribution.*
Available: http://www.geocities.com/Athens/Parthenon/1020/biome.html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BIOME NAME
CM RAIN
TEMP °C
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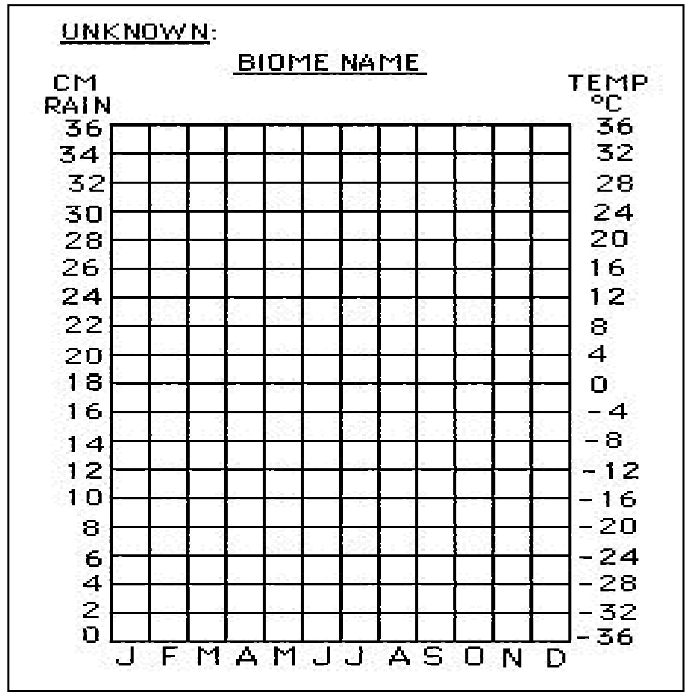
J F M A M J J A S O N D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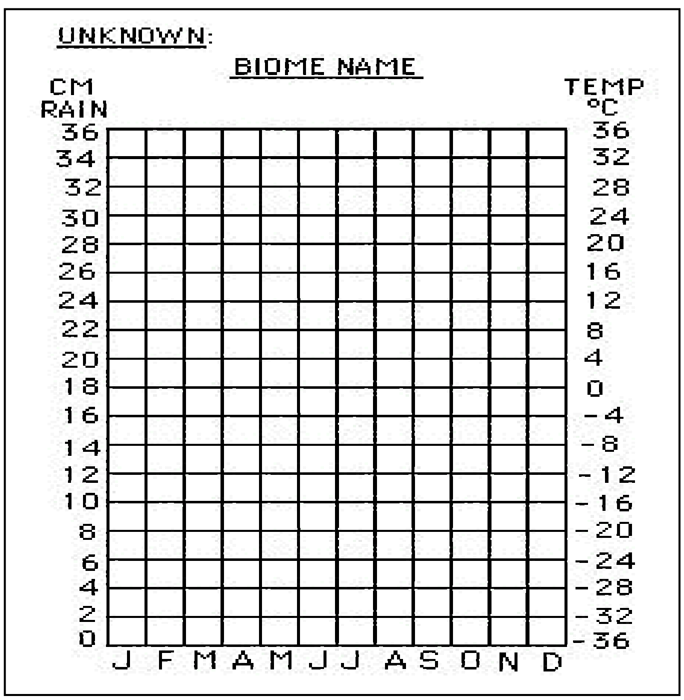
J F M A M J J A S O N D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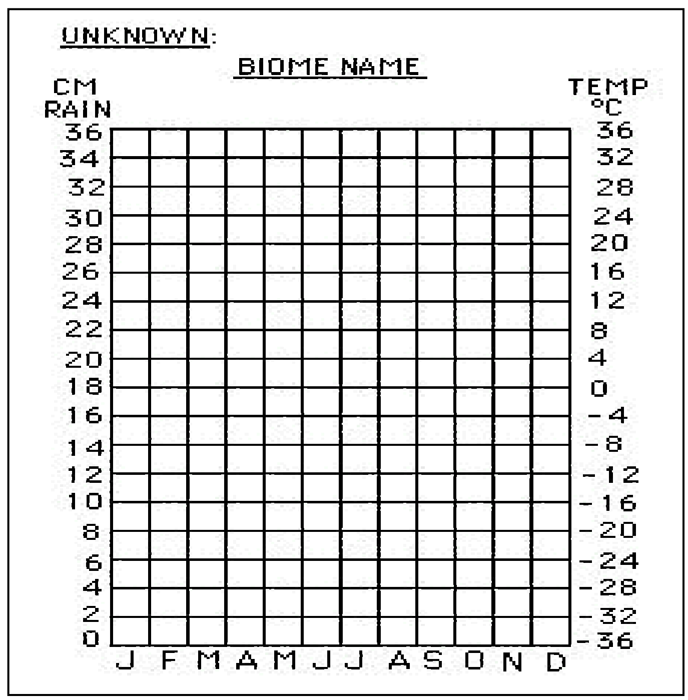
J F M A M J J A S O N D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J F M A M J J A S O N D

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 3: CLIMATE VARIABILITY

Estimated Time: One block

Indicator(s) Core Learning Goal 1:

1.5.4 The student will use tables, graphs, and displays to support arguments and claims in both written and oral communications.

1.5.5 The student will create and/or interpret graphics (scale drawings, photographs, digital images, field of view, etc.).

Indicator(s) Core Learning Goal 2:

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits: Climate type and distribution (temperature and precipitation.)

Student Outcome(s):

The student will be able to describe the difficulties of predicting changes in climate by analyzing temperature and precipitation data.

Brief Description:

Students decipher time-lapse weather maps, use graphs to predict how a region's conditions vary according to temperature and precipitation fluctuations, and analyze weather anomalies.

Background knowledge / teacher notes:

Excellent background information regarding climate and weather can be found at University Corporation for Atmospheric Research. *Introduction to Climate.*
Available: http://www.ucar.edu/learn/1_2_1.htm#top

Credit: Goddard Space Flight Center Earth and Space Sciences Education Project (GESSEP)
Principal Investigator: Steve Gilligan. Co-Investigator: Vern Smith
This lesson is based on the NASA Ambassador Investigation of the same name.

Earth/Space Systems Science
Unit IV: The Biosphere

Craig W. McLeod, Principal Investigator, Lisa Graby Bruck, Dan Hortert, and Marijke McMillian

Available: http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/kaboom.abstract.html

Lesson Description:

ENGAGE	Technology Connection: Directions: What are the current weather conditions in the United States? 1. Go to: *The Weather Channel - Current U.S. Weather* Available: http://www.weather.com/maps/satelliteusnational.html 2. Scroll down until "Satellite" appears. 3. Check a region that is to be investigated. 4. Get a U.S. national view. Discussion: 1. Locate weather fronts by looking for cloud lines. What type of fronts are these? 2. What direction do you think the clouds are moving? How can you tell? 3. What's the weather in Anne Arundel County? 4. Is this typical weather? How can we decide? *Examine the climate.*
EXPLORE	Technology Connection: What's the climate like in Anne Arundel County? 1. NOAA. *Selection Criteria for Displaying a Period of Record.* Available: http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgrg3.html 2. Select Maryland from the scroll list in "Select the State." 3. In the "Select the division number" section, select #4 (Anne Arundel County). 4. "Select the Parameter: choose "precipitation" then go down to

	"Generate Graph." ***Journal Write:*** 5. What is the range in years for the precipitation graph? 6. List six anomalies (extremes); the three years with the highest precipitation and the three years with the lowest precipitation. 7. Is our climate changing? Use evidence to support your answer. 8. Go back (1X) to "Select the Parameter;" choose "temperature". Scroll to "Generate the Graph."
EXPLAIN	***Journal Write:*** 1. Are there any anomalies? If so, during what year and month. 2. What major differences do you observe between the precipitation and the temperature graphs? 3. Would you say that your weather is normal for the climate or are you experiencing an anomaly? Use the data to support your response.
EXTEND	Working in groups of four, students investigate the influence of climate variability on predicting changes in climate. Climate Variability Materials per group of four: deck of playing cards, graph paper, transparency, overhead pens Directions: 1. Shuffle a deck of cards. 2. Black cards represent cooler average global temperatures for one year and red cards represent warmer average global temperatures. 3. Display 30 cards, one at a time. This will represent global average temperatures for 30 years. Look for a pattern. ***Journal Write:*** 4. Describe the pattern.

5. Gather the cards. Simulate the influence of global warming by removing four black cards from the deck. Remember: black cards represent cooler than average years.
6. Shuffle the deck.
7. Display 30 cards, one at a time.

Journal Write:

8. Describe the pattern.

9. Repeat these steps several times, each time removing four black cards.

Adaptive Strategy: Move around the room and ask students to explain what they've found so far in terms of climate, not cards.

Journal Write:

10. Make a graph of cooler and warmer years for the first 30-year period.
11. Make a graph of cooler and warmer years for the second 30-year period.
12. How many cards do you have to take out to make a noticeable change in a 30-year period?

G/T Connection: students analyze cards using assigned values.

Teacher note: Assign a value (amount of temperature increase or decrease) to each card. For example, assign the following values to the heart or diamond (red) cards:

Ace =	0.1°F temperature rise
Two =	0.2°F rise
Etc. through 10; 10 =	1.0°F rise
Jack =	1.5°F rise
Queen =	2.0°F rise
King =	2.5°F rise

	Compute the average global temperature change for the 30-year period. Repeat this several times, taking out four black cards each time. From University Corporation for Atmospheric Research. *Climate variability*. Available: http://www.ucar.edu/learn/1_2_2_9t.htm Discussion: 1. Using a transparency of their graphs, each group discusses their results with the class and looks for trends and differences. 2. Explain why we shouldn't expect all summers and winters to be warmer from now on if global warming is real.
EVALUATE	***Journal Write*:** Explain why it is difficult to predict changes in climate. Cite evidence to support your answer.

Materials per group of four:

- Deck of cards
- Graph paper
- Transparency
- Overhead pen

Earth/Space Systems Science
Unit IV: The Biosphere

What's the climate like in Anne Arundel County?

Go to NOAA. *Selection Criteria for Displaying a Period of Record.*

Available: http://lwf.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgrg3.html

1. Select Maryland from the scroll list in "Select the State."
2. In the "Select the division number" section, select #4 (Anne Arundel County).
3. "Select the Parameter: choose "precipitation" then go down to "Generate Graph."

Journal Write:

4. What is the range in years for the precipitation graph?
5. List six anomalies (extremes); the three years with the highest precipitation and the three years with the lowest precipitation.
6. Is our climate changing? Use evidence to support your answer.

7. Go back (1X) to "Select the Parameter;" choose "temperature". Scroll to "Generate the Graph."

Journal Write:

8. Are there any anomalies? If so, during what year and month.
9. What major differences do you observe between the precipitation and the temperature graphs?
10. Would you say that your weather is normal for the climate or are you experiencing an anomaly? Use the data to support your response.

Earth/Space Systems Science
Unit IV: The Biosphere

Climate Variability

Materials per group of four: deck of playing cards, graph paper, transparency, overhead pens

Directions:

1. Shuffle a deck of cards.
2. Black cards represent cooler average global temperatures for one year and red cards represent warmer average global temperatures.
3. Display 30 cards, one at a time. This will represent global average temperatures for 30 years. Look for a pattern.

Journal Write:

4. Describe the pattern.

5. Gather the cards. Simulate the influence of global warming by removing four black cards from the deck. Remember: black cards represent cooler than average years.
6. Shuffle the deck
7. Display 30 cards, one at a time.

Journal Write:

8. Describe the pattern.

9. Repeat these steps several times, each time removing four black cards.

Journal Write:

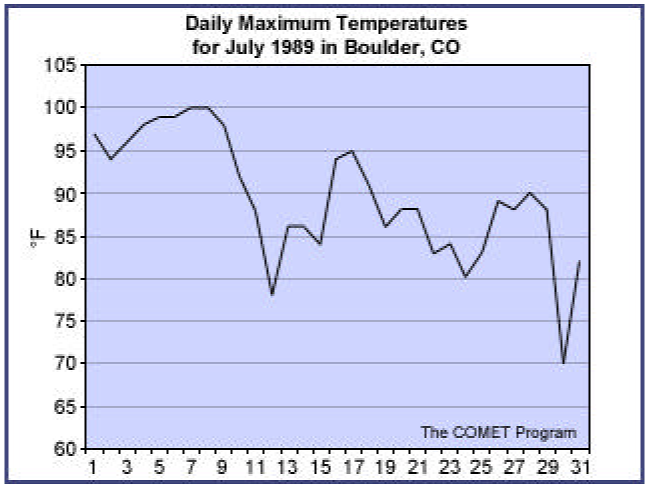
10. Make a graph of cooler and warmer years for the first 30-year period.

11. Make a graph of cooler and warmer years for the second 30-year period.
12. How many cards do you have to take out to make a noticeable change in a 30-year period?

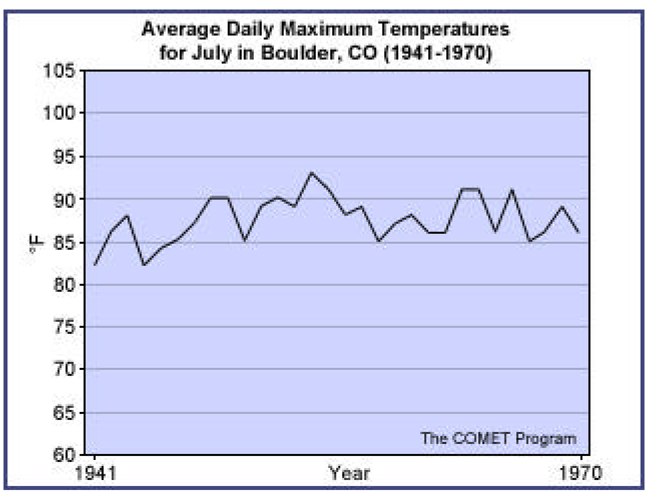
Earth/Space Systems Science
Unit IV: The Biosphere

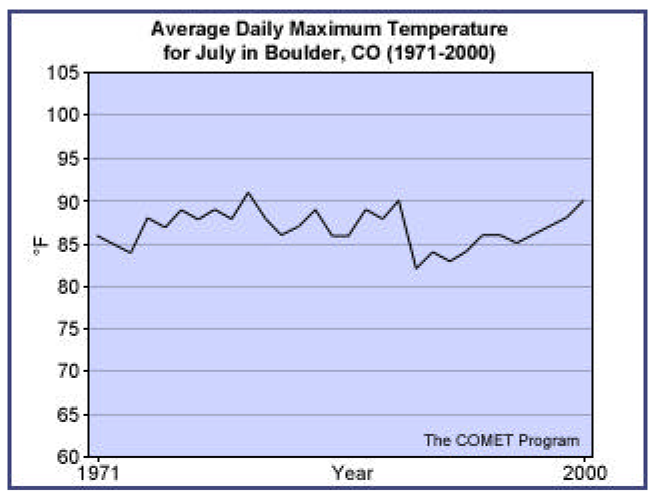
Climate Variability

Atmospheric scientists investigating the possibility that human influences are changing the earth's climate confront a significant problem: how do we actually detect climate change? We know that weather can be highly variable on a daily, weekly, or even yearly basis, but climate, which is based on longer time scales, can be variable as well. If the last 30 years were generally warmer worldwide than the previous 30 years, would this be solid evidence that the climate is changing in a particular direction? Or could this only be a long-term, normal statistical fluctuation in climate? This is a critical and surprisingly difficult question for atmospheric scientists to answer. While computer models may predict climate change, citizens are unlikely to support significant social, economic, and/or technological changes to slow the rate of change unless they are sure that the climate is truly changing, not just experiencing random variability. To begin answering these questions, it is important to understand what constitutes normal climate variability versus actual climate change. You can think of climate variability as the way climatic variables (such as temperature and precipitation) depart from some average state, either above or below the average value. For example, the average maximum temperature in July in Boulder, CO may be 87°F (averaged over the last 30 years), but each year, July's daily average maximum temperature will be less than or greater than this long-term average value. Similarly, for a given year (for example, 1989 as shown in the graphic), Boulder's mean maximum temperature for the month of July might be 90°F, but the maximum temperature on any given day within that month will depart from the monthly average value. Although daily weather data depart from the climatic mean, we consider the climate to be stable if the **long-term average** does not significantly change.



Climate change can be defined as a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the period of record. As we look at 30-year average values, however, we also detect variability. For example, the 30-year average July temperature from 1971 to 2000 is lower by approximately 1°F than that of 1941 to 1970.





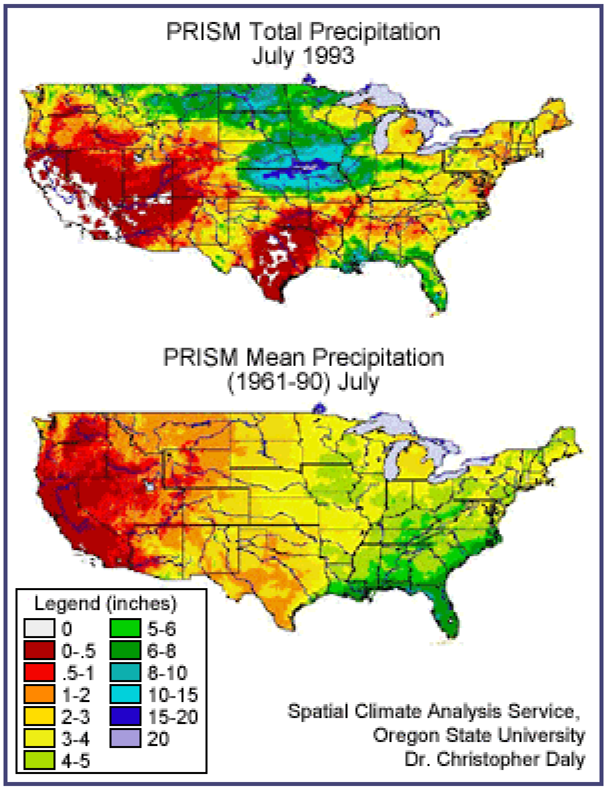
Does this mean that global climate change has started? Usually when we read about global climate change, we think of warming. In this case, we observed a slight cooling. Can we reasonably expect 1991 to 2020 averages for Boulder in July to be different still? Will they be warmer or cooler? It is very important to keep in mind that this is temperature data for one location only. If we had picked different years or even months to use as examples, we would likely see even different results. For example, during the same time period the global average yearly temperature has warmed, but at this location, for the month of July, the average temperature has cooled. This seemingly contradictory example illustrates the effect of your sample over time and space in determining climate trends.

Climatologists also grapple with the occurrence of "extreme" events. These are specific climate events that depart from the average in some significant way. For example, days that exceed 100°F in Boulder may be considered "extreme." While it's possible that any given summer day in Boulder might be 100+°F, under conditions of climatic warming, we would expect the frequency of such extreme days to increase. In other words, the probability that a given summer day would exceed 100°F would be higher under climatic warming than a stable climate.

Climatologists are concerned with more than temperature changes. Changes in precipitation are also of critical importance. Precipitation patterns that deviate significantly from the average can result in droughts or floods. The Midwest floods of 1993 are a recent and devastating example of an extreme event.

The Midwest Flood of 1993

The average July precipitation pattern for the thirty-year period from 1961 to 1990 for the United States was very different from the average July precipitation recorded in 1993 as shown on the map below.



Both climatic averages and the probability of climate extremes are, by definition, statistical measurements based on probabilities, not certainties. This makes the absolute detection of climate trends difficult to predict and very difficult to measure, except by looking at long-term historical data. Without waiting decades to decide whether climate change is "real" and whether we should respond, we are left to "play the odds."

From University Corporation for Atmospheric Research. *Climate variability.*
Available: http://www.ucar.edu/learn/1_2_2_9t.htm

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 4: HUMAN IMPACT - EL NIÑO AND LA NIÑA

Estimated Time: One block

Indicator(s): Core Learning Goal 1

1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions.

1.4.6 The student will describe trends revealed by data.

1.5.8 The student will describe similarities and differences when explaining concepts and/or principles.

Indicator(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits (at least) – Ocean-atmosphere-land interactions (current changes, continental movement, El Niño, La Niña)

Student Outcome(s):

1. The student will be able to determine the impact of El Niño/La Niña on Earth's biosphere by analyzing data and creating a graphing organizer.
2. The student will be able to evaluate the relationship between human activities and El Niño/La Niña by reading a technical passage and completing a writing activity.

Brief Description:

In this lesson, students review the characteristics of El Niño/La Niña. They will also determine how these phenomena affect human activities. Furthermore, they will investigate the possibility that human activities may influence El Niño/La Niña.

Background knowledge / teacher notes:

The El Niño Southern Oscillation (ENSO) Primer from the scientists at Goddard Space Flight Center is an excellent first look at El Niño. It will be especially useful for students who need a review of ENSO, or who may have entered class after this was covered earlier in the year. Audio and visual files may be downloaded from the web.

NASA GSFC. *The El Niño Southern Oscillation (ENSO) Primer*.
Available: http://nsipp.gsfc.nasa.gov/enso/primer/index.html

Lesson Description:

ENGAGE	Think-Pair-Share 1. What are the causes of El Niño/La Niña? 2. What are the characteristics of El Niño/La Niña? Adaptive Strategy Review the differences between El Niño and La Niña. Have the students visit NASA GSFC. *The El Niño Southern Oscillation (ENSO) Primer*. Available: http://nsipp.gsfc.nasa.gov/enso/primer/index.html Another useful site can be found at NOAA. *NOAA El Niño Page.* Available: http://www.elnino.noaa.gov/ Or similar reading passages may be used.
EXPLORE	Discussion: Look at the list of “El Niño Dates” (See resources). Describe any patterns that you notice. Adaptive Strategy Model use of the data table by selecting a year and interpreting it with the students. How are El Niño and La Niña related? How does one affect the other? Find out by visiting NASA. *El Niño Repellent?* Available: http://science.nasa.gov/headlines/y2001/ast28jun_1.htm

	Journal Write: Create a graphic organizer comparing El Niño and La Niña. <u>Adaptive Strategy</u>: Model the use of a Venn Diagram.
EXPLAIN	***Journal Write:*** 1. In what ways are El Niño and La Niña "opposites?" 2. Describe the impact of El Niño on Earth's biosphere.
EXTEND	Read to be informed about the impact of El Niño on the biosphere. Global Change. *El Nino Fades, But Still Packs a Punch*. Available: http://www.globalchange.org/monitall/98jul7.htm Discussion: 1. If El Niño has an impact on the biosphere, how might it affect human populations? 2. El Niño and La Niña can have an impact on human activities. Is it possible that human activities could alter El Niño and/or La Niña? Explore the effect of El Nino on health around the world. World Health Organization. *El Niño and Its Health Impacts*. Available: http://www.who.int/inf-fs/en/fact192.html <u>Multicultural Connection and G/T Connection</u>: Read about the impact of El Nino on Southeast Asia. Tiempo Climate Cyberlibrary. *Impact of El Niño and La Niña on Southeast Asia.* Available: http://www.cru.uea.ac.uk/tiempo/floor0/briefing/igcn/igcn2000.htm Materials per group of four: chart paper, markers, tape Working in lab groups, students create a poster describing the relationship between human activities and El Niño/La Niña. Conduct a gallery walk of the posters. INTEREST CENTER:

	Poway Unified School District. *El Niño or El No-no.* Available: http://www.powayschools.com/projects/elnino/
EVALUATE	***Journal Write:*** In a brief paragraph, describe the impacts of El Niño and La Niña on Earth's biosphere, including the impact on human activities. Cite evidence from you readings, and refer to your graphic organizers and poster.

Materials per lab group:

- Chart paper
- Markers
- Tape

El Niño Dates

The following table shows the distribution of El Niño (+) and La Niña (-) events, by month, for the period 1961-1990. Months with no symbol are considered "normal".

Month

Year	J	F	M	A	M	J	J	A	S	O	N	D
1961												
1962			-	-	-	-	-	-	-	-	-	-
1963				+	+	+	+	+	+	+	+	+
1964			-	-	-	-	-	-	-	-		
1965			+	+	+	+	+	+	+	+	+	+
1966												
1967								-	-	-	-	-
1968	-	-	-	-	-	-					+	+
1969	+	+	+	+	+							
1970			-	-	-	-	-	-	-	-	-	-
1971	-	-	-	-	-	-	-	-	-	-		
1972		+	+	+	+	+	+	+	+	+	+	+
1973	+			-	-	-	-	-	-	-	-	-
1974	-									-	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-
1976	-	-	-	+	+	+	+	+	+	+	+	
1977		-	-	-	-	-	-					
1978		-	-	-	-	-	-	-				
1979												
1980												
1981												
1982					+	+	+	+	+	+	+	+
1983	+	+	+	+	+	+	+	+	+			
1984										-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-							+	+	+	+
1987	+	+	+	+	+	+	+	+	+	+		
1988		+	+	+	+	+	+	+	+	+	+	+
1989	+	+	+									
1990												

Totals

	J	F	M	A	M	J	J	A	S	O	N	D
El Nino	5	6	7	8	9	8	8	8	9	8	8	7
La Nina	7	8	10	10	10	10	9	9	8	10	8	8
Normal	18	16	13	12	11	12	13	13	13	12	14	15

The source of this tabulation is the article: "Pacific Ocean Influences Atmospheric Carbon Dioxide", by Steven D. Meyers and James J. O'Brien. It was published in the December 26, 1995 issue of the *Transactions of the American Geophysical Union*.

Note: There is no official, agreed-upon definition of El Niño. Therefore, different researchers studying the phenomenon have come up with slightly different dates. The above tabulation represents one possible set of dates.

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 5: GREENHOUSE GASES AND CLIMATE CHANGE

Estimated Time: One block

Indicator(s) Core Learning Goal 1:

1.1.1 The student will recognize that real problems have more than one solution and decisions to accept one solution over another are made on the basis of many issues.

1.5.6 The student will read a technical selection and interpret it appropriately.

1.2.6 The student will identify appropriate methods for conducting an investigation (independent and dependent variables, proper controls, repeat trials, appropriate sample size, etc.).

Indicator(s) Core Learning Goal 2:

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits: Climate type and distribution (temperature and precipitation.)

Student Outcome(s):

The student will be able to analyze the impact of human activities on Earth's climate by comparing sources of atmospheric greenhouse gases.

Brief Description:

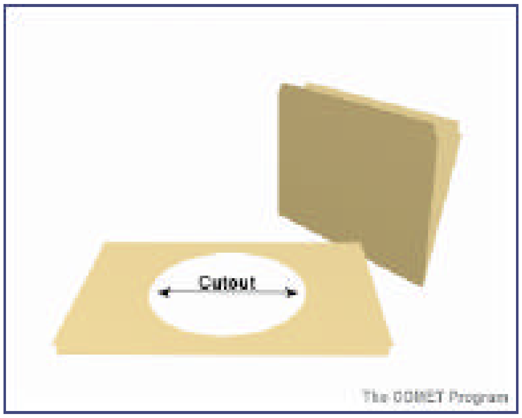
Students compare sources of carbon dioxide and determine the effect of human activities on levels of greenhouse gases. Using this information, they discuss how changes in greenhouse gases might lead to changes in climate.

Background knowledge / teacher notes:

Because of its properties, students can easily detect CO_2. When dissolved in water, carbon dioxide forms a weak acid, called carbonic acid. The chemical bromothymol blue (BTB) is a sensitive indicator of the presence of acid. When gas containing CO_2 is bubbled through a BTB solution, carbonic acid forms and the indicator turns from dark blue to green, yellow, or very pale yellow depending on the CO_2 concentration (lighter colors mean higher concentrations).

The students analyze the CO_2 from **their own breath** (representing animals), and **the outside air** by bubbling a known amount of each gas though a standard volume of BTB.

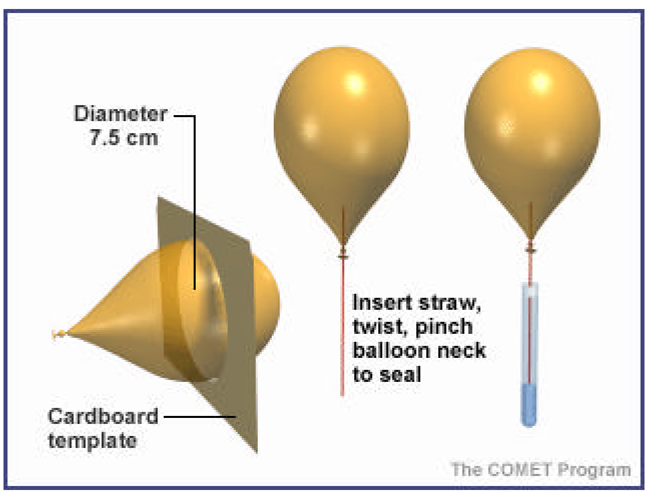
It is important that students collect equal volumes of gases by using balloons blown up to the same diameter from each source as collectors. To do this, make a simple balloon diameter template with a piece of cardboard or half of a manila folder. Draw a circle about 7.5 cm in diameter in the middle. Cut out the circle and discard, saving the frame for use as a template.



You will need one of these templates for each group of students. As they collect samples, the students can use these to make sure that the samples are of approximately equal volumes. The templates can be re-used.

How students bubble carbon dioxide through bromothymol blue

1. Insert the straw inside the neck of Balloon A and secure it with a twist tie. Do not remove the first twist tie (holding the balloon closed) at this time.
2. Insert the other end of the straw into the bromothymol blue solution in test tube A.
3. Insert a cotton ball into the top of the test tube to help hold the straw in place.



Gently release air from the balloon by slowly untwisting the first twist tie from the neck. Allow the air to bubble out at a steady rate until the balloon is empty. BE VERY CAREFUL TO ALLOW A SLOW AND STEADY GAS RELEASE

PART 2: QUANTIFYING CARBON DIOXIDE

To do this titration, add small volumes of a basic (high pH) solution (such as ammonia or other bases) to the bromothymol blue mixture and record how much of this solution it takes to make the bromothymol blue return to its original blue color. The more CO_2 bubbled through the bromothymol blue solution, the more ammonia required to restore the original color.

Sample data table

Levels of Carbon dioxide					
Test tube	Source of CO_2	Starting color of liquid	Color after treatment	Number of drops to return to blue	Rank (0 = least acidic)
A					
B					
C					

Lesson Description:

ENGAGE	Discussion: 1. What is the greenhouse effect? 2. What factors influence the greenhouse effect? *Clouds, albedo, ocean, forests* 3. How does the greenhouse effect influence climate? 4. What are the major greenhouse gases? *Carbon dioxide is important in maintaining the earth's average temperature of about 15°C (59°F). Without water vapor, CO_2, and methane (the three most important naturally produced greenhouse gases), the earth's surface would be about -18°C (0°F).* Adaptive Strategy: Read about factors that influence the Greenhouse Effect. (See resources). University Corporation for Atmospheric Research. *Teacher guide. What factors impact a Greenhouse?* Available: http://www.ucar.edu/learn/1_3_2_13t.htm Or other similar text passages may be used.

EXPLORE	Working in small groups, students diagram the carbon cycle. ***Journal Write:*** 1. Diagram the carbon cycle. 2. Label sources and sinks. Adaptive Strategy: Review the symbols used in drawing a systems diagram. Read to be informed about the carbon cycle. University Corporation for Atmospheric Research. *Teacher guide. What is the carbon cycle?* Available: http://www.ucar.edu/learn/1_4_2_15t.htm Or other similar text passages may be used. As a class, design an experiment to compare sources of carbon dioxide using bromothymol blue. Have lab materials on student's desks. Record class responses and experimental procedures on the board or overhead. Brainstorm: · Sources of carbon dioxide: *air, animals* · Methods for collecting carbon dioxide: *balloons* · How to test for carbon dioxide. Adaptive Strategy: Demonstrate how bromothymol blue can indicate the presence of carbon dioxide and how to quantify the amount of carbon dioxide through titration. ***Journal Write:*** Write a hypothesis predicting which source provides the most carbon dioxide. Sample Procedures: Sources of Carbon Dioxide Materials: 2 empty balloons, 3 test tubes, a test tube rack, a supply of

	bromothymol blue, a balloon size template, 3 straws, and 3 cotton balls, air pump, marker, funnel, masking tape *Directions for Collecting Samples:* *Outside Air (Sample A)* 1. Blow up one of the balloons to stretch out the rubber. 2. Using the pump, fill the balloon with outside air until its circumference is the same size as the balloon template. 3. Secure the balloon with a twist tie. 4. Label this 'Balloon A.' *Animals (Sample B)* 5. Blow up the second balloon to stretch out the rubber. 6. Blow up the balloon once more, using your breath, until its circumference is the same size as the template. Hold air in your lungs for a few moments to allow plenty of exchange between O_2 being absorbed and CO_2 being released in their lungs. Breaths that are too rapid will contain less CO_2 than normal exhalations. 7. Secure the balloon with a twist tie. 8. Label this 'Balloon B.' 9. Using masking tape and a marker, label each test tube (A, B, and C). 10. Fill each of the test tubes approximately 1/3 full of bromothymol blue. You may want to use the funnel to make this task easier. 11. Record the color of the solution in test tubes on the data chart. Tube C will be the control. 12. Insert the straw inside the neck of Balloon A and secure it with a twist tie. Do not remove the first twist tie (holding the balloon closed) at this time. 13. Insert the other end of the straw into the bromothymol blue solution in test tube A. 14. Insert a cotton ball into the top of the test tube to help hold the

	straw in place. 15. Gently release air from the balloon by slowly untwisting the first twist tie from the neck. Allow the air to bubble out at a steady rate until the balloon is empty. BE VERY CAREFUL TO ALLOW A SLOW AND STEADY GAS RELEASE. As carbon dioxide is bubbled through the bromothymol blue solution, it reacts with the water to form carbonic acid. The more CO_2 in the gas, the more acid is formed. As the pH of the solution becomes more acidic, the bromothymol blue changes from blue to green to yellow. 16. Observe the color change (if any). Record your observations on the data table. 17. Repeat the above steps for each of the balloons. 18. Compare the results of the test tubes. 19. Arrange the test tubes in order by color (yellow to blue). Hold a blank sheet of white paper behind the test tubes to observe color differences more easily. 20. Rank the test tubes by the amount of CO_2 present: 0 - 2. Keep the samples for part two. In part 2 you will determine the relative concentrations of CO_2 from the samples collected in Part 1. Materials: dropper bottle of ammonia or other base, stirring rod Directions: 1. Make sure the test tubes have equal amounts of bromothymol blue. 2. Using the dropper, add a drop of the base solution to test tube A. 3. Stir the solution after each drop. 4. Count the number of drops it takes to return each sample solution to the original blue color (see control test tube C for comparison). 5. Record the number of drops in the data chart. 6. Repeat the above steps for test tube B.

	7. The number of drops of base needed to turn the solution blue again is directly related to the amount of CO_2 required to change the bromothymol blue color in the first place. Modified from University Corporation for Atmospheric Research. *Activity 17: Where in the world is carbon dioxide?* Available: http://www.ucar.edu/learn/1_4_2_17s.htm
EXPLAIN	***Journal Write:*** 1. Which source contains the most carbon dioxide? 2. What is the difference in carbon dioxide content between the test tubes ranked 1 and 2? Adaptive Strategy: Model how to divide the number of drops needed to change the test tube ranked 2 by the number of drops used to change the test tube ranked 1.) 3. What is the difference in carbon dioxide content between the test tubes ranked 2 and 0? 4. Suppose you tested car exhaust. Predict the relative carbon dioxide content. Read about the relationship between greenhouse gases and temperature. (See resource) University Corporation for Atmospheric Research. *Activity 17: Where in the world is carbon dioxide?* Available: http://www.ucar.edu/learn/1_4_2_17s.htm ***Journal Write:*** You have examined several sources of CO_2. If you were to reduce the amount of CO_2 entering the atmosphere, which source would be most important to control? Use evidence to support your answer.
EXTEND	Discussion: 1. How have humans impacted greenhouse gases? 2. Brainstorm possible human sources of greenhouse gases.

3. Are the sources of greenhouse gases equally distributed throughout the world?

Materials per group of four**:** Graphs greenhouse gases and human activities (See resources), County map, Calculator

Working in small groups, students compare the greenhouse graphs with other graphs (for example, global temperature and human population increases) during the same time span.

From University Corporation for Atmospheric Research. *Teacher guide. Human Activity and Climate Change.*

Available: http://www.ucar.edu/learn/1_4_2_20t.htm

Journal Write:

What kinds of trends do you predict?

Directions:

1. Calculate the personal/family/class contribution of CO_2 due to vehicle use.
2. Using a county map (if necessary), estimate the distance (in miles) from your home to school.

   Identify the type of family vehicle based on the types listed in the table.

Vehicle	MPG	Pounds CO_2 per gallon
Compact car	24	20
Full-size car	16	20
Truck/Van	13	21
Bus	8	22*

3. Calculate the amount of gas used weekly if you rode to and from school everyday in a private car. To do this: Add up the total

	number of miles for 10 round trips to school (remember, if you are dropped off at school, the driver has to drive home, so there are 2 round trips a day). 4. Divide the total by the miles per gallon to determine the gallons of gas burned. 5. Multiply the CO_2 released per gallon. <u>Adaptive Strategy</u>: Model the calculations. If you live 4 miles from school, your car travels 16 miles per day to drop you off and pick you up, or 80 miles per week. At that mileage, a full-size car will burn 5 gallons of gas per week. Five gallons of gas will produce 100 pounds of CO_2 every week. 6. Calculate the class total as if everyone rode to school in a private vehicle. <u>G/T Connection:</u> Do the same calculations, using the figures for the bus and dividing the total CO_2 released by the approximate number of students that ride on the bus. Determine how many students walk or bike to school. They do not contribute additional CO_2 to get to and from school. Now re-calculate the class total based on the type of transportation actually used by students. Share these results with the class. ***Journal Write:*** 7. Compare the results. How much difference is there? 8. The United States has only a small percentage of the world's population but emits a disproportionate share of the global CO_2. China has a population of over a billion people. What would happen if China "developed" to the point where most families owned an automobile that emitted CO_2?

	Read to be informed about the relationship between greenhouse gases and changes in climate. Wheeling Jesuit University/NASA Classroom of the Future. *Exploring Global Climate Change. Remote Sensing: Precipitation.* Available: http://www.cotf.edu/ete/modules/climate/GCremote4.html Wheeling Jesuit University/NASA Classroom of the Future. *Exploring Global Climate Change. Remote Sensing: Temperature.* Available: http://www.cotf.edu/ete/modules/climate/GCremote3.html Or other similar text passages. ***Journal Write:*** Does an increase in greenhouse gases, such as carbon dioxide, affect climate? Use evidence from your reading to support your answer. INTEREST CENTER National Academy of Sciences. *A closer look at Global Warming.* Available: http://www4.nas.edu/onpi/webextra.nsf/web/climate?OpenDocument EPA. *Global Warming: Climate Uncertainties.* Available: http://yosemite.epa.gov/oar/globalwarming.nsf/content/ClimateUncertainties.html National Energy Information Center. Energy Information Administration. *Greenhouse Gases, Global Climate Change and Energy.* Available: http://www.eia.doe.gov/oiaf/1605/ggccebro/chapter1.html
EVALUATE	***Journal Write:*** How have human activities influence changes in climate? Use

	evidence from your investigations and readings to support your answer.

Materials per lab group:

- Dropper bottle of ammonia or other base
- Stirring rod
- 2 empty balloons 8 or 10-inch diameter
- 1 balloon full of car exhaust
- 3 test tubes
- Test tube rack
- Bromothymol blue
- Manila folder
- 3 straws
- 3 cotton balls
- Air pump: bicycle pump or sports ball pump
- Marker
- Funnel
- Masking tape
- Graphs greenhouse gases and human activities
- County map (optional)
- Calculator

Earth/Space Systems Science
Unit IV: The Biosphere

Where in the World is Carbon Dioxide?

Carbon dioxide (CO_2) is a significant greenhouse gas. Carbon dioxide is important in maintaining the earth's average temperature of about 15°C (59°F). The CO_2 traps infrared energy emitted from the earth's surface and warms the atmosphere. Without water vapor, CO_2, and methane (the three most important naturally produced greenhouse gases), the earth's surface would be about -18°C (0°F). At this temperature, it is doubtful that complex life, as we know it would ever have evolved.

Where does CO_2 come from? Plants and animals give it off when they extract energy from their food during cellular respiration. Carbon dioxide bubbles out of the earth in soda springs, explodes out of volcanoes, and is released when organic matter burns (such as during forest fires).

Anything that releases CO_2 into the atmosphere (living, dead, or non-living) is considered a source. Anything that absorbs and holds CO_2 from the air or water is considered a sink (because, like a sink in your home, it acts as a "holding reservoir")

Over geologic time, CO_2 sources and sinks generally balance. In today's atmosphere, however, CO_2 levels are climbing in a dramatic and easily measurable fashion, providing evidence that there are now more CO_2 sources than sinks.

What are the sources for this 'extra' CO_2? Human activities are thought to be primarily responsible for the observed increases. Of the human sources of CO_2:

- Fossil fuel combustion accounts for 65%
- Deforestation (CO_2) released from trees that are cut and burned or left to decay) accounts for 33%
- The by-products of cement production account for the remaining 2%

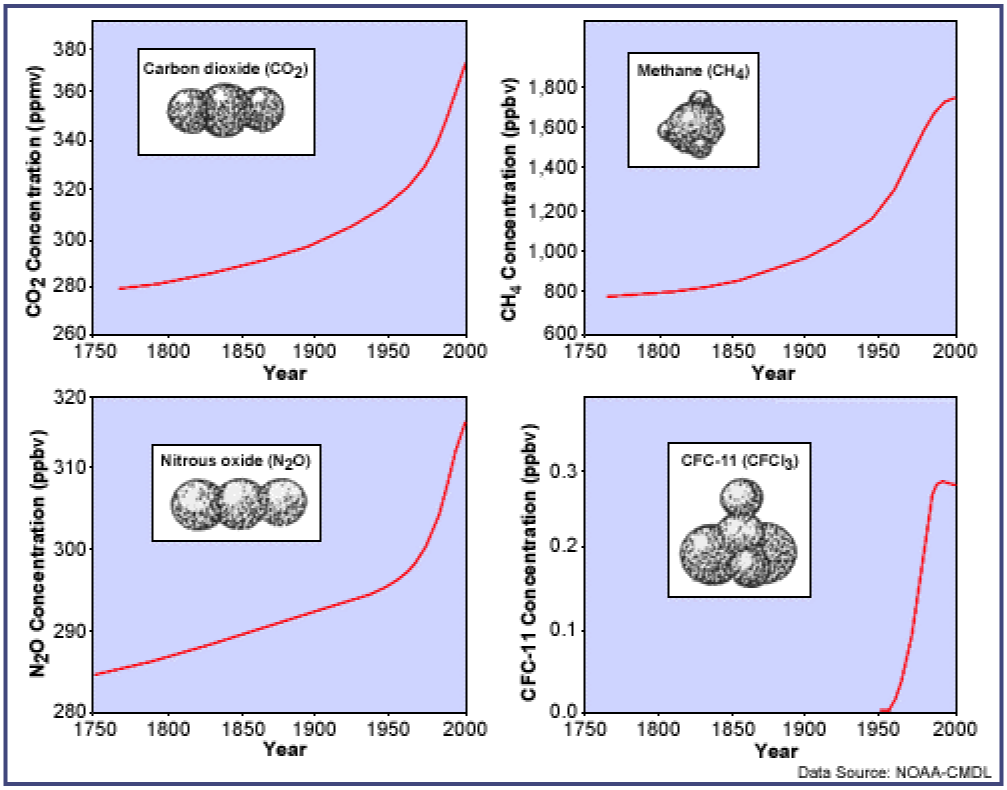
There are natural sources of CO_2 as well. Plants and animals give off CO_2 while alive and respiring and when dead and decaying (bacteria that consume the dead bodies respire too, after all). Carbonate rocks contain CO_2 that can be released by exposure to acid and/or weathering. Certain naturally carbonated spring waters (for example, Perrier water) contain CO_2 because the water has passed though carbonate rocks on its way to the surface. Volcanoes are also a source of CO_2. However, these geological sources are insignificant when compared to the human sources.

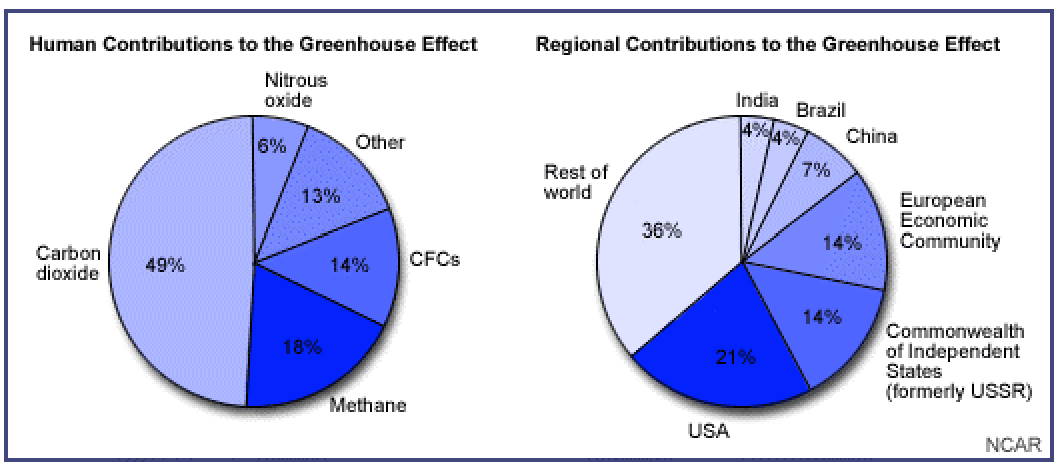
Plants (both terrestrial plants and marine phytoplankton) are the most important carbon sinks, taking up vast quantities of CO_2 through the process of photosynthesis. To a lesser extent, atmospheric CO_2 can also be dissolved directly into ocean waters and thereby be removed from the atmosphere. While plants also release CO_2 through the process of respiration, on a global, annual basis, the amount of CO_2 taken up by plants through photosynthesis and released through respiration approximately balances out. Thus, the CO_2 released from human activities is truly the 'extra' CO_2.

Scientists typically monitor the concentration of CO_2 in atmospheric samples by using sensitive devices called infrared gas analyzers. These devices pass a beam of infrared (IR) light through a sample of gas. The amount of IR that reaches a detector on the other side can be used to determine the amount of CO_2 in the sample. A worldwide network of CO_2 monitoring stations currently tracks the earth's rising CO_2 levels.

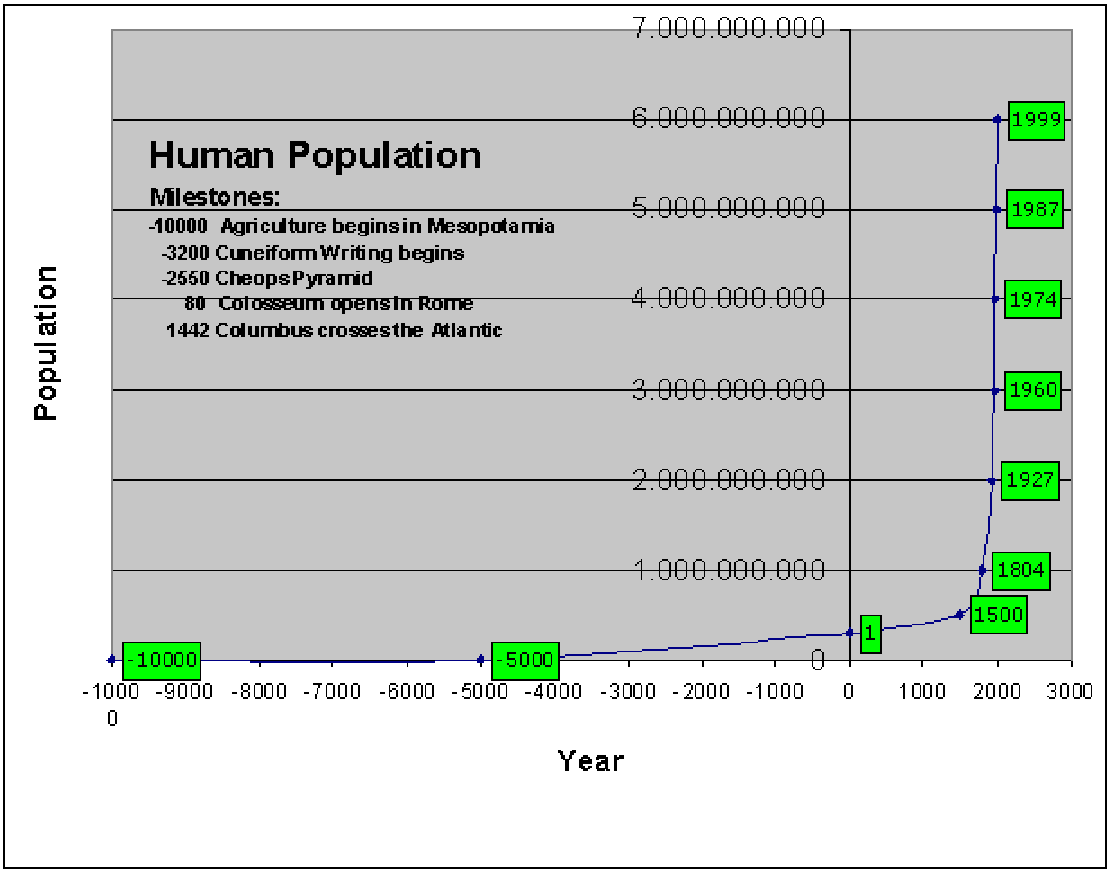
University Corporation for Atmospheric Research. *Activity 17: Where in the world is carbon dioxide?*
Available: http://www.ucar.edu/learn/1_4_2_17s.htm

Earth/Space Systems Science
Unit IV: The Biosphere

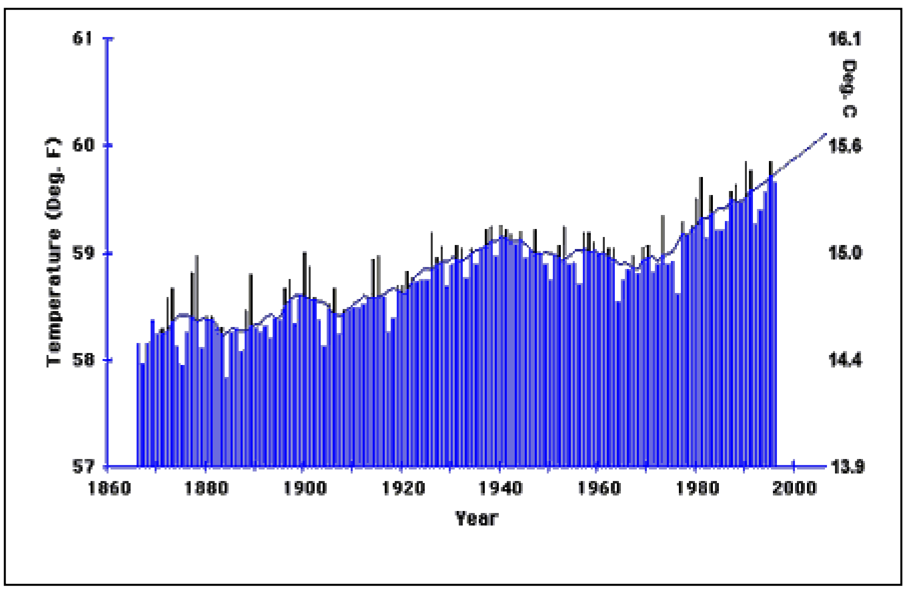




University Corporation for Atmospheric Research. *Teacher guide. Human Activity and Climate Change.* Available: http://www.ucar.edu/learn/1_4_2_20t.htm



International Starch Institute: *Human Population Graph.*
Available: http://home3.inet.tele.dk/starch/isi/energy/population.htm



EDF. *A Warming Century: The Past Hundred Years.*
Available: http://globalwarming.enviroweb.org/ishappening/warmcentury/

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 6: COASTLINES AND CHANGES IN SEA LEVEL

Estimated Time: Two blocks

Indicator(s) Core Learning Goal 1:

1.5.8 The student will describe similarities and differences when explaining concepts and/or principles.

1.6.3 The student will express and/or compare small and large quantities using scientific notation and relative order of magnitude.

Indicator(s) Core Learning Goal 2:

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter. Assessment limits: Climate type and distribution (temperature and precipitation.), Sea level, glaciers and sea ice, emergent and submergent coastlines.

Student Outcome(s):

1. The student will be able to correlate changes in ice sheets, sea level, and climate by reading a technical passage and interpreting data.
2. The student will be able to predict how changes in sea level affect coastlines by completing a computer simulation activity.

Brief Description:

In this lesson, students investigate the relationships among climate change, ice coverage, sea level, and coastlines.

Background knowledge / teacher notes:

As the weight and depth of a glacier increases so does the pressure on the bottom layers of the glacier. When a depth of 50 m is reached, the pressure changes the ice from a solid into a more flexible material and it begins to flow. Glaciers can also move through a sliding motion if they become unstable.

Ground observations, beginning in the late 1800s, and ground-based and satellite measurements in recent years, have shown that many glaciers in and near Glacier Bay have been receding, some rapidly. When a glacier recedes, water from the melting ice is released into the ocean and sea level rises. The greatest potential for sea-level rise is from melting of the Antarctic and Greenland ice sheets. However, the small glaciers of the world, such as those in Glacier Bay, would contribute about six-tenths of a meter to sea level if they were to melt completely.

The movement of glaciers can be monitored from satellites. Using computer techniques, the elevation can be determined from satellite images. This allows us to obtain a 3-dimensional perspective and actually appear to "fly-by" an area enabling more realistic visualization of the glacier.

Ground-based surveying may make precise measurements of glacier changes.
Maps drawn by early explorers of Glacier Bay, can be registered to, or overlain on, satellite images using computer techniques. Common, stable points between the map and the images are located and digitally overlain using image-processing techniques. One image is stretched in relationship to the other. Once the images are registered, we can measure changes in glacier-terminus position, from the time of the earliest maps, to the present. Maps drawn by earlier explorers of Glacier Bay, can be registered to, or overlain on, satellite images using computer techniques. Common, stable points between the map and the images are located and digitally overlain using image-processing techniques. One image is stretched in relationship to the other. Once the images are registered, we can measure changes in glacier-terminus position, from the time of the earliest maps, to the present.

The once enormous Muir Glacier, located in what is now in the East Arm of Glacier Bay was named for John Muir, the famous naturalist and explorer who visited Glacier Bay in the late 19th century. In 1905, just 26 years after Muir's first visit, Freemont Morse wrote:
"Formerly the Muir presented a perpendicular front at least 200 feet in height, from which huge bergs were detached at frequent intervals. The sight and sound of one of these vast masses falling from the cliff, or suddenly appearing from the submarine ice-foot, was something which once witnessed, was not to be forgotten. It was grand and impressive beyond description. Unfortunately the recent changes in the Muir have not increased its impressiveness from a scenic

standpoint. Instead of the imposing cliff of ice, the front is sloping, and seems to be far less active than formerly."

The Muir Glacier is now but a small remnant of its former glory, and has nearly retreated up out of the ocean. In fact, many of the large tidewater glaciers that John Muir first observed in 1879 have been reduced to small glaciers that terminate on land. Land that is uncovered as glaciers recede permits plant and animal life to appear and flourish.

Measurements of the Muir Glacier have shown that the terminus retreated up the Muir Inlet at a rate of about four-tenths of a kilometer per year, between 1794 and 1892, for a total retreat of more than 40 kilometers. Satellite measurements, derived from images acquired in 1973, 1980, 1983 and 1986, show that the Muir Glacier went back more than 7 kilometers between 1973 and 1986, with most of that retreat occurring between 1973 and 1983.

Reprinted from narrated script written by NASA glaciologist Dorothy Hall for the NASA video *Glacier Bay, Alaska, from the Ground, Air and Space***.**

Available: http://sdcd.gsfc.nasa.gov/GLACIER.BAY/glacierbay.script.html

Teacher note: Glacier Bay from the Ground, Air and Space. (Video) NASA

To obtain a copy of this video send email to Dr. Dorothy K. Hall at dhall@glacier.gsfc.nasa.gov or write her at the following address:

Dorothy K. Hall, Ph.D.
Hydrological Sciences Branch/Code 974
Laboratory for Hydrospheric Processes
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

If you wish to make the land ice sheet model instead of viewing the simulation (Texas A&M University.Ocean Drilling Distance Learning Program. *Sea Level: Ice Volume Changes. Exercise 1.)*

Available: http://oceandrilling.coe.tamu.edu/curriculum/Sea_Level/Ice_Volume/index.html

you will need:

10 gallon aquarium: dimensions 20"X10"X12" (can be purchased at Walmart)

Medium-sized mixing bowl (2 quart sized, to make the iceberg)

Measuring tape or stick to track water level changes

Food coloring or Blue Kool-Aid to color the water

Make the Continental Shelf from scraps of wood:

8"X10" piece of 3/8" thick plywood

1.75"X8" piece of 3/8" plywood

2 pieces of 7"X2" (1" thick) plywood

3.5"X2" piece of 1" thick plywood

7 wood screws (1")

Lesson Description:

ENGAGE	Technology Connection: NASA. *Glacier Bay, Alaska, from the Ground, Air and Space***.** Available: http://sdcd.gsfc.nasa.gov/GLACIER.BAY/glacierbay.script.html Select *Muir Glacier terminus* (click to see Java Applet) Or go directly to NASA. *Glacier Bay, Alaska, from the Ground, Air and Space*. *Muir Glacier*. Available: http://sdcd.gsfc.nasa.gov/GLACIER.BAY/java.tidewater/example1.html Observe the photos taken in 1973, 1980, 1983 and 1986. Other images of the Muir Glacier's retreat are located at EOS. NASA. *Retreat of the Muir Glacier*. Available: http://eospso.gsfc.nasa.gov/eos_edu.pack/p30.html Class discussion: 1. Predict the type of climate that allowed the glacier to form. 2. Predict how changes in climate might affect glaciers.

	Read to be informed about ice ages. Illinois State Museum. *Ice Ages.* Available: http://www.museum.state.il.us/exhibits/ice_ages/index.html Or other similar text passages. ***Journal Write:*** 1. What are Ice Ages? 2. When did Ice Ages occur? 3. Why do Ice Ages occur? Technology Connection: View a short illustration of the last ice age at Illinois State Museum. *Ice Ages.* Available: http://www.museum.state.il.us/exhibits/ice_ages/index.html
EXPLORE	What happens to sea level during ice ages? Read to be informed about changes in sea level. Create a graphic organizer to record information from the reading. Texas A&M University. Ocean Drilling Distance Learning Program. *Sea Level: Ice Volume Changes.* Available: http://oceandrilling.coe.tamu.edu/curriculum/Sea_Level/Ice_Volume/index.html Teacher Note: Read the Introduction through Exercise 1. Don't miss the simulations in exercise 1. G/T Connection: Read NASA. *GCMD Learning Center. Is Sea Level Rising*? Available: http://gcmd.gsfc.nasa.gov/Resources/Learning/sealevel.html Or other similar text passages.
EXPLAIN	***Journal Write:*** 1. Is sea level rising? Use evidence from the reading to support your answer. 2. What factors influence changes in sea level?

	3. Predict how changes in sea level might affect us.
EXTEND	Technology Connection: View Antarctic Ice Sheet Animation. The animation begins with Antarctica at the peak of last ice age 18,000-20,000 years ago and shows how the West Antarctic Ice Sheet has changed since that time Texas A&M University. Ocean Drilling Distance Learning Program. *Sea Level: Ice Volume Changes. Exercise 2.* Available: http://oceandrilling.coe.tamu.edu/curriculum/Sea_Level/Ice_Volume/activity3.htm Teacher Commentary during animation: "During the last 20,000 years, the west Antarctic ice sheet lost two-thirds of its mass and raised the sea level 10 meters. It still contains enough ice to raise the sea level by another 5 meters if it were to lose the remainder of its mass." CNN.com. *NASA animates 20,000 years of Antarctic ice history.* Available: http://www.cnn.com/TECH/science/9902/03/antarctic.ice.sheet/ ***Journal Write:*** 1. How has the coastline of Antarctica changed since the peak of the last ice age? *retreated* 2. How has the shrinking of the west Antarctic Ice Sheet affected sea level? *Raised sea level 10 meters.* Teacher During the last 30 years, scientists have become increasingly concerned about the possible effects of global warming on the west Antarctic ice sheet. The majority of the west Antarctic ice sheet sits atop dry land, while the east Antarctic ice sheet is grounded below sea level. Changes in the east Antarctic sheet would have little effect on sea

	levels since the ice displaces water, but a complete melt of west Antarctic ice would pour new water into the oceans. ***Journal Write:*** 1. How much will sea level rise if the Antarctic ice cap were to melt? Adaptive Strategy: Allow students to use a calculator. Model the calculations that are needed. Calculations: · Convert the volume of the ice caps to the volume of water it represents. The volume of ice on Antarctica is approximately 29,315,965 km^3. Since ice is about 90% as dense as water, multiply by 0.9 to obtain the volume of ice after it's melted. *The ice volume to water volume of the ice sheets:* *Antarctica: 26384368.5 km^3* · Estimate the amount of sea level rise by dividing the water volume of an ice sheet by the total surface area of the oceans. The total water area of the earth's oceans and seas is 346,976,563 km^2. *Sea level estimates were calculated by dividing the water volume of the ice sheets by the total surface area of the oceans and seas:* *Antarctica: .07604078 km= 76.04078 m* *Please note: there are approximations and uncertainties in several of the numbers used in these calculations so the answers should be considered only roughly correct.* From Museum of Science, Boston. *Visualizing Sea Level Rise.* Available: http://www.secretsoftheice.org/icecore/sealevel.html Views map of Greenland. Point out land areas covered by ice. University of Texas. *Greenland.* Available: http://sunsite.informatik.rwth-aachen.de/Maps/islands_oceans_poles/greenland.jpg

	2. How much will sea level rise if the Greenland ice sheet were to melt? · Convert the volume of the ice caps to the volume of water it represents. The volume of ice on Greenland it is 2,604,142 km^3. *The ice volume to water volume of the ice sheets:* *Greenland: 2342727.8* km^3 · Estimate the amount of sea level rise by dividing the water volume of an ice sheet by the total surface area of the oceans. The total water area of the earth's oceans and seas is 346,976,563 km^2. *Sea level estimates were calculated by dividing the water volume of the ice sheets by the total surface area of the oceans and seas:* *Greenland: .006751833 km = 6.751833m* *Please note: there are approximations and uncertainties in several of the numbers used in these calculations so the answers should be considered only roughly correct.* From Museum of Science, Boston. *Visualizing Sea Level Rise.* Available: http://www.secretsoftheice.org/icecore/sealevel.html Have students compare their predictions with the scientists. USGS Science for a Changing World. *Estimated Present-Day Area* and Volume* of Glaciers and Maximum Sea Level Rise Potential.* Available: http://pubs.usgs.gov/fs/fs133-99/gl_vol.html Students observe how changes in sea level affect coastlines. Assign each pair of students one of the following areas of the world to observe: U.S. East Coast, Florida, Northern Europe, Southeast Asia, NOVA. *Warnings from the Ice. Water World.* Available: http://www.pbs.org/wgbh/nova/warnings/waterworld/ ***Journal Write:*** 1. Describe how the coastline of your area looked 20,000 years ago.

	2. How was your area affected by the 17-foot rise in sea level? 3. Where should you live in your area to be safe from a 17-foot rise in sea level? How concerned should we be about glaciers/ice sheets melting in our lifetime? Read "How Fast Can a Glacier Change?" Rice University. *Ice. How Do Glaciers Deal With Environmental Change?* Available: http://www.glacier.rice.edu/land/5_glaciersandtheir2.html#anchor88458 ***Journal Write:*** 1. How concerned should we be about ice sheets melting in our lifetime? 2. How concerned should we be about small valley glaciers melting in our lifetime? Use evidence from the reading to support your answers. INTEREST CENTER Texas A&M University. Ocean Drilling Distance Learning Program. *Sea Level: Ice Volume Changes. Exercise 4 Ice Cores.* Available: http://oceandrilling.coe.tamu.edu/curriculum/Sea_Level/Ice_Volume/activity5.htm
EVALUATE	***Journal Write:*** 1. How have ice sheets changed during Earth's history? Cite examples from your reading. 2. What is the relationship among change in ice sheets, sea levels, and climate? Use evidence from your reading and from the simulation

	activities.

Materials per lab group:

- Map of Greenland
- Map of Antarctica
- Calculator

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Lesson 7: GLOBAL WARMING AND POLLUTION – ANALYZING THE ISSUES

Estimated Time: One block

Indicator(s) Core learning Goal 1:

1.1.3 The student will critique arguments that are based on faulty, misleading data or on the incomplete use of numbers.

1.1.5 The student will explain factors that produce biased data.

1.4.3 The student will use experimental data from various investigators to validate results.

1.4.6 The student will describe trends revealed by data.

Indicator(s): Core Learning Goal 2:

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter.

Assessment limits (at least) – Atmospheric composition and structure (greenhouse gases, stratospheric ozone concentration and distribution, aerosols, temperature), Pollutants (particulates, tropospheric ozone concentration and distribution, acid rain)

Student Outcome(s):

The student will be able verify or refute the significance of global warming by analyzing data and creating an editorial.

Brief Description:

In this lesson, students analyze data and trends on global warming and air pollution. Based on their conclusions, they will debate whether or not scientific evidence supports concern over global warming and air quality.

Background knowledge / teacher notes:

The greenhouse effect is the trapping of heat inside Earth's atmosphere by greenhouse gases. The most significant greenhouse gases are carbon dioxide, methane, and water vapor. The heat that is trapped helps keep Earth habitable. However, too much trapped heat could result in massive climate changes leading to drought, rising sea level, and shifts in agriculture.

Scientists are not in agreement regarding the greenhouse effect and its role in global warming and climate change. Some feel that the data indicates a problem; others suggest that the data is inconclusive. Since greenhouse gases and the raw materials for tropospheric ozone have common sources, increased levels of tropospheric ozone could accompany potential global warming. Again, air quality experts have differing opinions. These controversies are the heart of this lesson.

Background information about heat budgets and climate change can be found at the following websites:
NASA GSFC. *Watching Your Heat Budget: Analyzing Temperature Changes in the Atmosphere.* Available:
http://education.gsfc.nasa.gov/experimental/July61999siteupdate/inv99Project.Site/Pages/trl/inv2-1.abstract.html#inv2-1.background

NASA's Office of Earth Science. *Southeast Regional Climate Assessment.*
Available: http://www.ghcc.msfc.nasa.gov/regional/

The data table for the average temperatures can be found at
NOAA. *Sterling Climate Page.*
Available: http://www.nws.noaa.gov/er/lwx/climate.htm
When going to this site, be sure to enter Washington, DC as your location. Students may use individual computers to view these sites or they may view them from a single computer. Or, the image can be printed as a transparency and shown to the entire class.

Lesson Description:

ENGAGE	Discussion: Moving away from the sun, the first four planets in our solar system

	are: · Mercury · Venus · Earth · Mars Place them in order from hottest to coolest. *Although Mercury is closest to the sun, Venus has a higher surface temperature due to high concentrations of carbon dioxide in its atmosphere and a resulting greenhouse effect. A lack of greenhouse gases on Mars produces a range of daily average temperatures that extend above and below those experienced on Earth.*
EXPLORE	Think-Pair-Share · Based on previous lessons, what are the causes and effects of global warming? · How are greenhouse gases from cars, factories, etc. related to increases in tropospheric ozone levels? ***Journal Write:*** Create a graphic organizer comparing greenhouse gases and tropospheric ozone. <u>Adaptive Strategy</u>: Remind students that car exhaust and industrial pollution contains greenhouse gases such as H_2O vapor and CO_2. These emissions also contain NO_x and hydrocarbons that react with sunlight to form O_3, ozone. What does scientific evidence tell us about "global warming?" Is it a serious threat to our planet? Do increasing ozone levels pose a serious health threat? Visit the following websites for different perspectives

	on global warming. The Detroit News. *Global Warming Got You Down* Available: http://www.sepp.org/reality/GWgotyoudown.html The U.S. Environmental Protection Agency. *Global Warming.* Available: http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html Environmental Defense Fund. *Global Warming: Focus on the Future.* Available: http://globalwarming.enviroweb.org/ Union of Concerned Scientists. *Global Warming* Available: http://www.ucsusa.org/ Climatehotmap.org. *Global Warming: Early Warming Signs.* Available: http://www.climatehotmap.org/index.html NASA. *Scientists Present 1998 Earth-Temperature Trends.* Available: http://science.nasa.gov/newhome/headlines/essd12jan99_1.htm The Atlantic Online. *Breaking the Global-Warming Gridlock.* Available: http://www.theatlantic.com/issues/2000/07/sarewitz.htm NASA Marshall Space Flight Center. *Accurate "Thermometers" in Space.* Available: http://science.msfc.nasa.gov/newhome/headlines/essd06oct97_1.htm NASA MISR. *MISR's Study of Atmospheric Aerosols.*

	Available: http://www-misr.jpl.nasa.gov/introduction/goals2.html#jump National Center for Policy Analysis. *Myths of Global Warming.* Available: http://www.ncpa.org/ba/ba230.html PBS. *What's up with the Weather? The Debate* Available: http://www.pbs.org/wgbh/warming/debate/ Adaptive Strategy Show students a set of yearly annual temperatures and ask them to determine if there the data indicates a global warming trend.
EXPLAIN	Materials: poster paper, marker, tape ***Journal Write:*** Working in small groups, create a Venn Diagram poster comparing evidence for and against global warming. Include possible links to increased levels of tropospheric ozone. Conduct a gallery walk of completed posters.
EXTEND	Working in groups, students discuss whether scientific evidence supports global warming and/or justifies concern over increases in tropospheric ozone. ***Journal Write:*** 1. Is global warming a threat to our planet? If so, does it require immediate attention? If not, why are people so concerned about it? 2. Do the data support a link between greenhouse gas emissions and health risks due to tropospheric ozone? Cite evidence from your reading.

	Working with your group, create an editorial that summarizes your findings about global warming and the threat of tropospheric ozone. Be sure to include: · data that supports your statement. · the organization (government, university, private researcher, etc.) responsible for the data. · an acknowledgment of scientists with opposing points of view, along with data you feel they have overlooked or misinterpreted. Your editorial may be in the form of a letter, poster, brochure, or public service announcement. <u>G/T Connection</u>: Design an action plan explaining how citizens, working in their communities, can reduce the effects of global warming and ozone pollution. <u>G/T Connection</u>: Compare the atmospheres of Mercury, Venus, Earth, and Mars. What factors and processes are responsible for the differences among these four planets? Based on past trends and current conditions, predict how atmospheric and temperature conditions may continue to evolve on these planets.
EVALUATE	***Journal Write***: Based on evidence presented by the class, do global warming and ozone pollution pose a health threat? Cite examples from students editorials.

Materials per lab group:

- Poster paper
- Markers
- Tape

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Lesson 8: POLLUTION IN THE TROPOSPHERE

Estimated Time: blocks

Indicators(s) Goal 1: Skills and Processes

1.2.7 The student will use relationships discovered in the lab to explain phenomena observed outside the laboratory.

1.4.2 The student will analyze data to make predictions, decisions, or draw conclusions.

1.7.1 The student will apply the skills, processes, and concepts of biology, chemistry, physics, and earth science to societal issues.

1.7.2 The student will identify and evaluate the impact of scientific ideas and/or advancements in technology on society.

Indicators(s) Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alters the transfer of energy and matter. Assessment limits (at least) Atmospheric composition and structure (greenhouse gases, stratospheric ozone concentration and distribution, aerosols, temperature), Pollutants (particulates, tropospheric ozone concentration and distribution, acid rain)

Student Outcome(s):

The student will be able to explain how natural and human changes affect global conditions by reading technical selections, analyzing data, and conducting a laboratory investigation.

Brief Description:

In this lesson, students investigate atmospheric pollution from human activities. In particular, they will study the origins of ozone in the troposphere. By making and using Schoenbein paper, they will also detect small-scale variations in ozone concentration.

Background knowledge / teacher notes:

Water vapor is the most common gas released by volcanoes on Earth: sulfur dioxide, carbon dioxide and hydrogen are released in smaller amounts; Finally, carbon monoxide, hydrogen sulfide, and hydrogen fluoride are also released, but usually in amounts less than 1 percent by volume. Volcanic gases combine with liquid water droplets in the atmosphere to form aerosols, giving rise to a variety of meteorological phenomena, such as acid rain. Both the ash and the aerosols produced by volcanoes have a short-term cooling effect on Earth's surface temperature.
Reprinted with permission from *Volcanoes Blow Their Top*
Pat Keeney Principal Investigator Roy Avedon, Lynn Birdsong, Robert Swanson.
Available: http://edmall.gsfc.nasa.gov/inv99Project.Site/Pages/trl/inv4-3.html

Christian Friedrich Schoenbein discovered ozone in 1839 during his tenure as a professor at the University of Basel, Switzerland. He used the reactivity of ozone to measure its presence and demonstrate that it is a naturally occurring component of the atmosphere. He developed a way to measure ozone in the troposphere using a mixture of starch, potassium iodide, and water spread on filter paper. The paper, called Schoenbein paper, changes color when ozone is present. Ozone causes iodide to oxidize into iodine (I_2). This test is based on the oxidation capability of ozone. Ozone in the air will oxidize the potassium iodide on the test paper to produce iodine. The iodine reacts with starch, staining the paper a shade of purple. The intensity of the purple color depends on the amount of ozone present in the air. The darker the color, the more ozone is present. The reactions involved are $2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$
I_2 + starch --> blue color

Teacher note: This activity works best in areas of low humidity and high ambient ozone concentrations. In some parts of the country, this activity may not be very conclusive. The amount of time needed for this experiment will vary depending on the nature of the student experiment, but each exposure will take 8 hours. Because relative humidity affects results, Schoenbein paper should not be left outside during periods of high humidity.

Schoenbein Paper Preparation

Materials: potassium iodide, distilled water, spray bottle, filter paper, hot plate, corn starch, glass stirring rod (do not use metal), small paint brush, 250 mL beaker, Pyrex plate, hot pad or mitt, 8 1/2 x 11 inch paper

1. Place 100 ml of distilled water in a 250 ml beaker.
2. Add 1 1/4 teaspoon of corn starch.
3. Heat and stir mixture until it gels. The mixture is gelled when it thickens and becomes somewhat translucent.
4. Remove the beaker from the heat source and add 1/4 teaspoon of potassium iodide and stir well. Cool the solution before applying to the filter paper.
5. Lay a piece of filter paper on a glass plate, or hold it in the air, and carefully brush the paste onto the filter paper. Turn the filter paper over and do the same on the other side. Try to apply the paste as uniformly as possible.
6. Wash hands after applying the potassium iodide mixture. (Although potassium iodide is not toxic, it can cause mild skin irritation.)
7. Set the paper out of direct sunlight and allow it to dry. A low temperature-drying oven works well if available.
8. Cut the filter paper into 1-inch wide strips.
9. To store the paper, place the strips in a sealable plastic bag or glass jar out of direct sunlight.

Adapted from University Corporation for Atmospheric Research. *Activity 29: Making and Using Schoenbein Paper*.

Available: http://www.ucar.edu/learn/1_7_2_29t.htm

Lesson Description:

ENGAGE	Think-Pair-Share 1. Besides N_2 and O_2, what other gases are found in Earth's atmosphere? *CO_2 and H_2O vapor* 2. Why are these gases important? *They are greenhouse gases that help regulate Earth's temperature* 3. What pollutants are in our atmosphere? 4. Where do they come from? *Cars, factories, volcanoes, forest fires…*

EXPLORE	Read to be informed about how natural events contribute to pollution and affect climate. Adaptive Strategy: Preview new vocabulary terms prior to reading. ***Journal Write:*** Create a graphic organizer to record information about substances released from volcanoes, the effects of these substances and the impact on climate. NASA EO DAAC. *Volcanoes and Climate Change.* Available: http://eob.gsfc.nasa.gov/Study/Volcano/ Or NASA facts online: *Volcanoes and Global Cooling.* Available: http://pao.gsfc.nasa.gov/gsfc/service/gallery/fact_sheets/earthsci/volcano.htm Or *Climate Cooling*. Available: http://volcano.und.nodak.edu/vwdocs/Gases/climate.html G/T Connection: NOAA. *Volcanic Ash advisories.* Available: http://www.ssd.noaa.gov/VAAC/washington.html ***Journal Write:*** Examine real time data of volcanic ash emissions. Have students compare emissions over several days.
EXPLAIN	Small group discussion: Using information from the reading and your graphic organizer, discuss the following questions. 1. How do volcanoes affect the atmosphere? *As volcanoes erupt, they blast huge clouds into the atmosphere. These clouds are made up of particles and gases, including sulfur dioxide. Millions of tons of sulfur dioxide gas can reach the stratosphere from a major volcano. There, the sulfur dioxide converts to tiny persistent sulfuric acid (sulfate) particles,*

	referred to as aerosols. 2. How do volcanic emission influence climatic changes? *Global cooling often has been linked with major volcanic eruptions. Sulfate particles reflect energy coming from the sun, preventing the sun's rays from heating Earth thus lowering temperatures in the troposphere, and changing atmospheric circulation patterns.*
EXTEND	Think-Pair-Share Another possible effect of a volcanic eruption is the destruction of stratospheric ozone. Researchers now are suggesting that ice particles containing sulfuric acid from volcanic emissions may contribute to ozone loss. When chlorine compounds resulting from the breakup of chlorofluorocarbons (CFCs) in the stratosphere are present, the sulfate particles may serve to convert them into more active forms that may cause more rapid ozone depletion. 1. Why is the ozone layer important to us? 2. Since ozone is so important to us, why are human activities that produce ozone considered pollution? *Tropospheric ozone* Read to be informed about tropospheric ozone. University Corporation for Atmospheric Research. *Tropospheric Ozone, the Polluter*. Available: http://www.ucar.edu/learn/1_7_1.htm ***Journal Write:*** Create a graphic organizer to record information about tropospheric ozone. Summarize the impact of increased tropospheric ozone on living organisms. G/T Connection: Read "A Typical Polluted Day in Los Angeles." (See resources) Cerebrawn, LLC. *A Typical Polluted Day in Los Angeles.* Available:

http://bigmac.cee.mtu.edu/home/classes/ce459/public/p27/POLLDAY.HTM

Journal Write:

Describe the relationship between changes in air pollution during the course of a day and human activities.

Teacher-led Discussion:

The amount and location of ozone in the troposphere is measured using NASA's TOMS satellite, but we can measure it using Schoenbein paper. *Ozone in the air will oxidize the potassium iodide on the test paper to produce iodine. The iodine reacts with starch, staining the paper a shade of purple. The intensity of the purple color depends on the amount of ozone present in the air. The darker the color, the more ozone is present.*

The reactions involved are $2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$

I_2 + *starch _ blue color*

Materials: distilled water, spray bottle, unused Schoenbein test strips and exposed test strips showing the presence of ozone.

1. Model how to use Schoenbein paper and interpret the results. *Spray a strip of test paper with distilled water and hang it at a data collection site out of direct sunlight. Expose the paper for at least eight hours. To determine if ozone is present, spray the paper with distilled water and look for a color change.*

Materials: distilled water, spray bottle, Schoenbein test strips

Journal Write:

1. Write a hypothesis about the relationship between location and the amount of ozone present.
2. Design an experiment to detect and measure ozone in the environment.
3. Create a data table to record results.

Sample procedures:

	1. Spray a strip of test paper with distilled water and hang it at a data collection site out of direct sunlight. Make sure the strip can hang freely. 2. Record the location of each test strip. 3. Expose the paper for at least eight hours. 4. Collect the test strips. Teacher Note: If the strips are not going to be tested immediately, place them in an airtight container. 5. To determine if ozone is present, spray the paper with distilled water and look for a color change. ***Journal Write:*** 6. Record your observations in the data table. Based on University Corporation for Atmospheric Research. *Activity 29: Making and Using Schoenbein Paper.* Available: http://www.ucar.edu/learn/1_7_2_29t.htm Class discussion: How have human activities negatively affected our atmosphere and climate? Suggest ways that we can counteract these harmful affects. G/T Connection: Using additional strips of Schoenbein paper, test additional areas throughout the community. ***Journal Write:*** 1. Create an ozone map that depicts your ozone data. 2. Suggest reasons for any patterns or variations. INTEREST CENTER University of North Dakota. *Volcanic Gases and the Origin of the Atmosphere.* http://volcano.und.nodak.edu/vwdocs/Gases/origin.html

	NASA. *Ozone Detection and Monitoring.* Available: http://apollo.lsc.vsc.edu/classes/remote/ labs/satlabs/s02/gab_ozone.ppt
EVALUATE	***Journal Write:*** 1. Explain how natural events such as volcanic emissions have influenced climate. Use evidence from your technical selection and data analysis to support your answer. 2. Describe the impact of human activities on global conditions. Use evidence from your technical selections and laboratory investigation to support your answer.

Materials per lab group:

- Potassium iodide
- Distilled water
- Spray bottle
- Filter paper
- Hot plate
- Corn starch
- Glass stirring rod
- Small paint brush
- 250 mL beaker
- Pyrex plate
- Hot pad or mitt

Earth/Space Systems Science
Unit IV: The Biosphere

A Typical Polluted Day in Los Angeles

The evolution of smog follows a predictable pattern: The primary pollutants are emitted beginning in the morning hours when human activity starts in earnest. The primary compounds cook under the sun to form secondary pollutants, which accumulate into the afternoon. Finally, after dusk, with activity winding down, the photochemical pollutants can disperse to other regions.

Meteorological and topographical influences are crucial factors in smog formation in an urban air shed. In general, the existence of a strong temperature inversion overhead and the marine boundary layer offshore establish the conditions for heavy smog in the basin. The initial development of the smog is tied closely to the sources of primary pollutants from automobiles and industries. The morning rush hour injects tons of primary pollutants into the early-morning boundary layer. A sea breeze (wind blowing inland from the coast) develops during the day as the sun heats the inland areas. Sunlight also cooks up the primary pollutants into full-blown smog. The sea breeze carries the layer of smog toward higher terrain, which traps it. Later, during the evening the land cools and the sea breeze dies down. The inversion layer drops, and pollutants may begin to be advected away in the upper-level winds.

The worst smog episodes occur when the air is stagnant over the Los Angeles basin, trapped below a strong regional temperature inversion associated with high pressure. During such an episode, the pollutants generated may linger for several days. The smog accumulates, producing very high concentrations of secondary pollutants. These conditions may eventually lead to an alert and actions to stem the flow of primary pollutants. The agenda for a smoggy day in Los Angeles can be summarized in the following phases:

Between about 6:00 A.M. and 9:00 A.M., the morning vehicle traffic is the densest, and the emissions of CO, NO, and RH are the greatest. Business and industrial activities begin during this period as well, and continue through the day. In the early morning the winds are often stagnant, and the inversion layer is very low (sometimes only a few hundred feet above the ground). Marine clouds and fog may be present in the coastal regions, carried inland the previous night with cooler air flowing from the ocean boundary layer. Pollution left over from the previous day may be trapped in narrow layers close to the surface.

The primary emissions continue, with a small boost around lunchtime. From about 9 A.M. through the early afternoon (roughly 2 P.M.) the primary emissions are photochemically transformed into the secondary pollutants (NO2, O_3 and HC). In the late morning, the sea breeze picks up and transports the coastal pollution inland. Near noon, the intensity of the sun maximizes, and secondary pollutants are generated rapidly. Ozone peaks in the afternoon hours.

By this time, ozone concentrations have accumulated to the highest levels. The sun has warmed the land and the sea breeze is quite strong, pushing a cloud of smog far inland against the mountains. At this point, the air laden with pollutants can be lofted through mountain passes onto the high plateau beyond. From there, the pollution can travel hundreds of miles across the desert regions.

In the late afternoon and early evening commuter traffic again builds up, and more primary pollutants are released into the smoggy air. The primary emissions peak between 5 and 7 P.M. However, the sun is lower in the sky, and so radiation is to small to generate much photochemical smog. The primary pollutants themselves accumulate. With one of the key ingredients for ozone formations removed (sunlight) the ozone concentrations begin to fall. The sea breeze continues to sweep the pollutants inland, diluting their effects closer to the coast.

In the late evening and early morning, the sea breeze dies down, and a weaker land breeze may develop. By this time, radiative cooling has created a low-level temperature inversion. Most of the previous day's pollution is left above this inversion and is dispersed by prevailing regional winds. On the other hand, primary emissions at the surface, which continue during the evening, can accumulate below the nighttime inversion.

The behavior of the principal smog pollutants has been carefully monitored in Los Angeles for many years. The data collected by the AQMD reveal many interesting relationships among the sources of primary pollutants, meteorology, and other factors contribution to smog formation.

Cerebrawn, LLC. *A Typical Polluted Day in Los Angeles.*
Available: http://bigmac.cee.mtu.edu/home/classes/ce459/public/p27/POLLDAY.HTM

Earth/Space Systems Science
Unit IV: The Biosphere

Lesson 9: MASS EXTINCTION

Estimated Time: One block

Indicator(s): Core Learning Goal 1

1.2.1 The student will identify meaningful, answerable scientific questions.

1.5.6 The student will read a technical selection and interpret it appropriately.

1.7.1 The student will apply the skills, processes, and concepts of biology, chemistry, physics, and earth science to societal issues.

Indicator(s): Core Learning Goal 2

2.3.2 The student will explain how global conditions are affected when natural and human-induced change alter the transfer of energy and matter.
Assessment limits (at least) –Atmospheric composition and structure, pollutants, climate type and distribution

Student Outcome(s):

The student will be able to analyze how species respond to natural and human-induced changes in Earth's biosphere by investigating causes and effects of mass extinction.

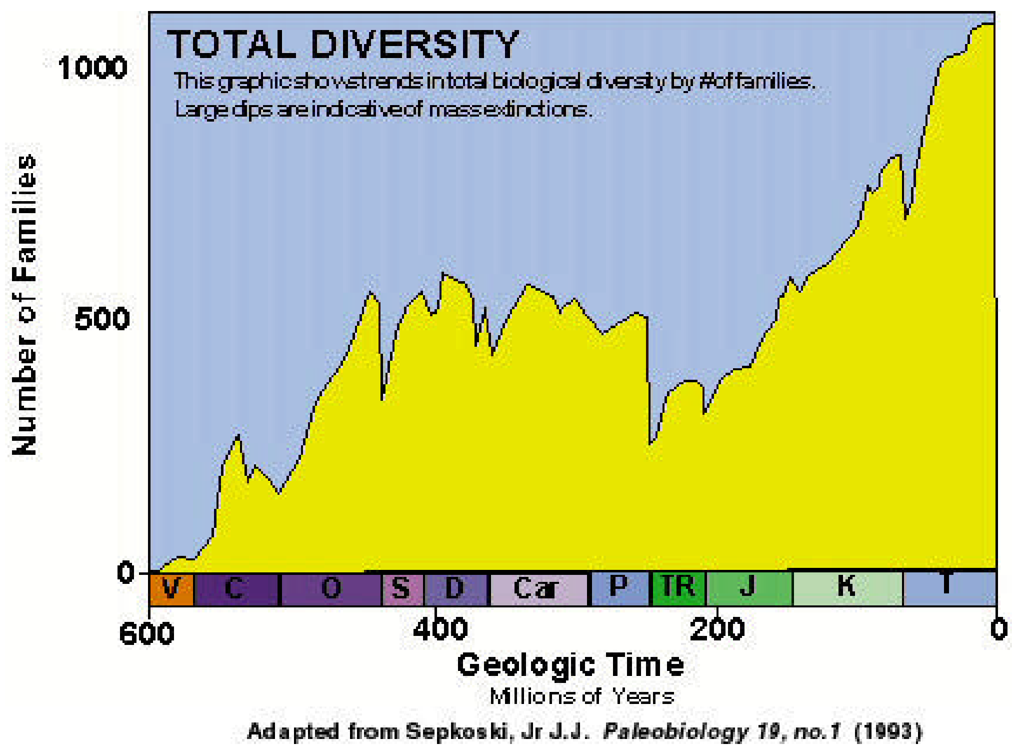
Brief Description:

At different points in the earth's history, large number of species went extinct in a relatively short time. In this lesson, students examine theories about the causes of mass extinctions. Evidence supporting these theories is analyzed, and students determine how these events affected the biosphere. Students consider ways in which humans influence the rate of extinction for different species.

Background knowledge / teacher notes:

65 million years ago, 60 to 80% of all life on this planet died. This is not the first time Earth has experienced mass extinctions. The fossil record shows a pattern of extinctions occurring roughly ever 26 million years. Scientists tend to agree that there have been 5 or 6 mass extinctions.

What could account for these mass extinctions? The list of suggested explanations is long, but most include some type of geologic (volcanoes), cosmic (asteroids), climatic (hot versus cold), and pathogenic (diseases) change. Currently the majority of evidence supports the idea that the Earth was struck by a large meteor 10-20km in diameter forming the Chicxulub Crater on the Yucatan peninsula in Mexico. Some scientists disagree and suggest that massive volcanic eruptions could have precipitated the catastrophe.



The last segment of the Mesozoic Era, from 135 to 65 millions of years ago, is called the Cretaceous Period. The first segment of the Cenozoic Era, from 65 million years ago until the present, is called the Tertiary Period. The abbreviation for the boundary between the Cretaceous and Tertiary periods is the K-T boundary, where K is the abbreviation for the German form of the word Cretaceous.

From NASA/UA Space Imagery Center's Impact Cratering. *Chicxulub impact Event and the K-T Boundary*.

Available: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Chicx_title.html

Lesson Description:

ENGAGE	Read the following account of The Year Without a Summer to the class. (See resources) NOAA. *The year without a summer.* Available: http://wchs.csc.noaa.gov/1816.htm Think-Pair-Share 1. What would be the result if these global climate changes continued for an extended period of time? *Famine, war, migration to different climate…* 2. What happens to those species that cannot adapt to rapid changes in climate? *Possible extinction*
EXPLORE	Teacher-led discussion: 1. Examine a graph showing history of mass extinctions. NASA/UA Space Imagery Center's Impact Cratering. *Chicxulub impact Event and the K-T Boundary.* Available: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Chicx_title.html Or Cornell. *A Mathematical Model for Mass Extinction*. Available: http://www.lassp.cornell.edu/newmme/science/extinction.html 2. Locate the areas of mass extinctions. *Most scientists agree that there were five mass extinctions.* 3. The latest mass extinction occurred 65 million years ago at what is known as the K-T boundary. Discuss the significance of this boundary. *This boundary corresponds to one of the*

	greatest mass extinctions in Earth's history, marking the end of age of reptiles and the beginning of the age of mammals. During this extinction at least 75 percent of the species on our planet, both in the oceans and on the land, disappeared forever. The most famous of the vanquished were the dinosaurs. However, these giants were only a small fraction of the plants and animals that disappeared, all land animals over about 55 pounds went extinct, as did many smaller organisms. In the oceans, more than 90 percent of the plankton was extinguished, which inevitably led to the collapse of the oceanic food chain. 4. What might have caused this mass extinction? *The most commonly accepted cause is that a meteor 10 km in diameter struck the Earth forming the Chicxulub Crater.* Adaptive Strategy: View the simulation of an asteroid forming the Chicxulub crater. If this hypothesis were correct, what evidence should scientists look for? Teacher Note: If necessary, demonstrate the formation of a crater by dropping a large object (asteroid) into a pan of flour. The object of this demonstration is to scatter dust over a large area. NASA/UA Space Imagery Center's Impact Cratering. *Chicxulub impact Event and the K-T Boundary.* Available: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Chicx_title.html
EXPLAIN	***Journal Write:*** Create a graphic organizer to record information about the causes and effects of the K-T mass extinction. Read to be informed about the K-T mass extinction.

	NASA/UA Space Imagery Center's Impact Cratering. *Chicxulub impact Event and the K-T Boundary.* Available: http://www.lpl.arizona.edu/SIC/impact_cratering/Chicxulub/Chicx_title.html Adaptive Strategy: Focus on the regional and global effects. Model how to use the dictionary located under the student/teacher button. ***Journal Write:*** How could the impact of an asteroid cause worldwide mass extinctions? Use evidence from the graphic organizer to support your answer.
EXTEND	Class discussion: 1. Review the graph of mass extinctions. 2. Brainstorm other causes of mass extinctions. Have each small group select one of the extinctions to investigate. Read to be informed about causes of mass extinctions. Suggested Websites: Space.com. *The Five Worst Extinctions in Earth's History.* Available: http://www.space.com/scienceastronomy/planetearth/extinction_sidebar_000907.html Hooper Virtual Paleontology Museum. *Mass Extinctions of Earth's History.* Available: http://hannover.park.org/Canada/Museum/extinction/permcause.html ***Journal Write:***

	1. What do scientists think is the cause of the mass extinction you are investigating? 2. What evidence supports this theory? 3. Do you agree with the theory the scientists have suggested? Cite evidence or data to support your answer. Not all extinctions are the result of natural changes. Read about how humans have affected species diversity. World Resources Institute. *A History of Extinction.* Available: http://www.wri.org/biodiv/b03-koa.html Or University of Florida. *UF Researcher: Humans make extinction happen 100 times faster*. Available: http://www.napa.ufl.edu/oldnews/extinct1.htm Or University of Michigan. *Ecological Role of Prehistoric Humans.* Available: http://www-personal.umich.edu/~dallan/nre220/outline4.htm G/T Connection: Explore the possibility that we are in a period of mass extinction now. California Institute of Integral Studies in San Francisco. *Mass Extinction Underway.* Available: http://www.well.com/user/davidu/extinction.html#anchor18171 ***Journal Write:*** 1. How have human activities impacted life on this planet? Use evidence from your reading in your answer. 2. To what degree can our activities delay or prevent the extinction of any species, including our own?

EVALUATE	***Journal Write***: 1. How have natural events impacted life on this planet? 2. How might human activities influence rates of extinction?

Materials:

- Mass Extinction graph
- Pan
- Flour

The Year Without a Summer

By Patrick Hughes

The year 1816 is legendary in the annals of weather. It has been called "the year without a summer", "poverty year," and "eighteen hundred froze to death."

From May through September, an unprecedented series of cold spells chilled the northeastern United States and adjoining Canadian provinces, causing a backward spring, a cold summer, and an early fall. There was heavy snow in June and frost even in July and August. All across the Northeast, farmers' crops were repeatedly killed by the cold, raising the specter of widespread famine.

The amazing weather of 1816 is well documented in the diaries and memoirs of those who endured it. Benjamin Harrison, a farmer in Bennington, Vermont. termed it "the most gloomy and extraordinary weather ever seen." Chauncey Jerome of Plymouth, Connecticut, writing in 1860, recalled "I well remember the 7th of June. . . dressed throughout with thick woolen clothes and an overcoat on. My hands got so cold that I was obliged to lay down my tools and put on a pair of mittens...On the 10th of June, my wife brought in some clothes that had been spread on the ground the night before, which were frozen stiff as in winter. On the 4th of July, I saw several men pitching quoits in the middle of the day with overcoats on and the sun shining bright at the time."

Since relatively few settlers had yet crossed the Mississippi, most of our weather observations for 1816 come from the eastern United States, particularly the Northeast, where there was a tradition of weather watching. The best observations available were made at Williamstown, in the northwestern corner of Massachusetts.

April and May 1816 were both cold months over the Northeast, with frost retarding spring planting. Flowers were late in blooming and many fruit trees did not blossom until the end of May - only to have their budding leaves and blossoms killed by a hard frost which also destroyed corn and some other plants.

Warm weather finally came to all parts of the Northeast during the first few days of June. Farmers forgot the frost of May and began replanting their crops. But even as they labored, a cold front was approaching that would bring disaster.

Following the frontal passage, temperatures tumbled dramatically under the onslaught of Arctic air. At noon on June 5, the temperature at Williamstown was 83 degrees. By 7am on the 6th, it had dropped to 45 degrees - the highest temperature recorded for the day. All across central New England, early morning temperatures were the highest recorded for the day.

From June 6 to 9, severe frost occurred every night from Canada to Virginia. Ice was reported near Philadelphia and "every green herb was killed, and vegetables of every description very much injured." In northern Vermont, the ice was an inch thick on standing water while elsewhere in the state icicles were to be seen a foot long... corn and other vegetables were killed to the ground, and upon the high lands the leaves of the trees withered and fell off."

People shivered, dug out their winter clothing and built roaring fires. Farmers watched helplessly as their budding fields and gardens blackened and in northern towns newly shorn sheep, though sheltered, perished. Thousands of birds also froze to death, as did millions of the yellow cucumber bug.

The culmination of this remarkable cold wave came early on the 1lth of June: At Williamstown the observer noted, "Heavy frost-vegetables killed at 5 o'clock temperature 30.5 degrees." Overall, frost killed almost all the corn in New England, the main food staple, as well as most garden vegetables.

There were two snowfalls. The first on the 6th brought relatively light snow to the highlands of western and northern New York State and most of Vermont, New Hampshire, and Maine. The second occurred during the night of June 7-8, following the passage of a second cold front. It brought moderate to heavy snow to northern New England, with lighter snow and snow flurries extending eastward to the coast and southward through northern Massachusetts and New York State's Catskill Mountains.

The following account appeared in the Danville, Vermont, North Star: Melancholy Weather . . . On the night of the 7th and morning of the 8th a kind of sleet or exceeding cold snow fell, attended by high wind, and measured in places where it drifted 18 to 20 inches in depth. Saturday morning (8th) the weather was more severe than it generally is in the winter. It was indeed a gloomy and tedious period.

In Canada, Montreal had snow squalls on both the 6th and 8th of June, while 12 inches of snow accumulated near Quebec city from the 6th to the 10th, with some drifts "reaching the axle tress of carriages."

This first summer cold spell was followed by 4 weeks of relatively good weather. Farmers again replanted, and crops were growing well when, at the end of the first week in July, a new cold outbreak came. Although not as severe as the one in June, it killed corn, beans, cucumbers, and squash in northern New England, and soon had local farmers talking about the threat of a general famine.

Once again, the remainder of the month was more seasonable, though there was another cool spell around the 18th. The hardier grains such as wheat and rye, however, came along well, and by August farmers were joking about their earlier "famine fever."

On August 20, another cold wave arrived, tumbling temperatures in New Hampshire some 30 degrees. During the next 2 days, frost was reported as far east as Portland, Maine, and as far south as East Windsor, Conn. Travelers between Albany, New York and Boston reported most of the corn in low-lying areas destroyed.

A more severe frost came at the end of August: In Keene, NH., it put an end to the hopes of many corn growers, and whole fields had to be cut up for fodder.

The first week of September was relatively warm, but around the 11th and 12th a cold outbreak again visited the Northeast with hard frost reported in northern and central New England. it was the widespread and killing frost of September 27th however, which irrevocably closed out this dismal growing season and destroyed all hopes of even a small corn harvest in northern New England.

A Concord N.H, paper reported: Indian corn on which a large portion of the poor depend is cut off. It is believed that through New England scarcely a tenth part of the usual crop...will be gathered. In Montreal it was said that... many parishes in Quebec must inevitably be in a state of famine before winter sets in. During the severe winter of 1816-1817 which followed, the threat of starvation or semi-starvation became reality for many.

The first general migration from New England to the Midwest occurred the following year. Although there were other factors involved, it is interesting to note that the three northern States of Vermont, New Hampshire, and Maine, which bore the brunt of the cold weather, suffered the greatest exodus.

In summary, the chief weather abnormalities of 1816 were the series of totally unexpected cold spells that occurred continuously through late spring, summer, and early fall and of course, the June snow.

New England temperatures averaged 3 to 6 below normal in June and July, and 2 to 3 degrees below in August. May also had been below normal as was the following September. It had been just as cold (or even colder) in each of these months in other years, but never consecutively. More significant however, is the fact that in 1816 the low temperatures occurred in a region where even a few degrees difference in the minimum temperature can mean a severe frost.

Although the New England farmer considered it a local tragedy, the abnormal weather was widespread throughout the Northern Hemisphere. In England it was almost as cold as in the United States, and 18l6 was a famine year there, as it was in France and Germany.

Actually, 1816 was just one of a famous series of cold years. From 1812 it was cold over the whole world. In the United States, the depression of summer temperatures was the most remarkable on record.

Stop Reading:

According to William Humphreys, a Weather Bureau scientist writing almost a century later, the cold years were caused largely by volcanic dust in the earth's atmosphere: Such dust partially shields the Earth from the Sun's rays, but permits heat to escape from the Earth, thus lowering the temperature.

Three major volcanic eruptions took place between 1812 and 1817. Soufriere on St. Vincent Island erupted in 1812; Mayon in the Philippines in 1814; and Tarnbora on the island of Sumbawa in Indonesia in 1815. The worst was Tambora, a 13,000-foot volcano that belched f1ame and ash from April 7 to 12, 1815; and rained stone fragments on surrounding villages.

It has been estimated that Tambora's titanic explosion blew from 37 to 100 cubic miles of dust, ashes, and cinders into the atmosphere, generating a globe-girdling veil of volcanic dust.

The idea that volcanic dust suspended in the atmosphere might lower the Earth's temperature has been around for a long time. Like many other scientific firsts, it can be traced to Benjamin Franklin, although the thought may not have been original with him. In 1913, William Humphreys published a now classic paper documenting the correlation between historic volcanic eruptions and worldwide temperature depressions.

According to Humphreys, volcanic dust is some 30 times more effective in keeping the Sun's radiation out than in keeping the Earth's in. And once blown into the atmosphere-more specifically; the stratosphere it may take years for the dust to settle out (the finest particles from Krakatoa's eruption in 1883, for example, took 2 to 3 years to reach the ground.) During this period the average temperature of the whole world may drop a degree or two; while local losses can be considerably greater.

The chief effect however, as in 1816, seems to be the dramatic depression of minimum temperatures during the summer. A weak sunspot maximum also preceded the cold summer of 1816. During May and June, these blemishes on the face of the Sun grew large enough to be seen with the naked eye and people squinted at them through smoked glass.

In Humphreys day, sunspots were thought to reduce the amount of solar radiation emitted and during a period of maximum occurrence, to depress the Earth's average temperature by as much as a half degree. As a result, sunspots also were blamed for the trials of the New England farmer in 1816. Humphreys showed, however, that whatever the historic correlation between the Earth's average temperature and the occurrence of sunspot maximums, the most pronounced dips in the world temperature curve were, without exception, associated with violent volcanic eruptions that exploded great quantities of dust into the stratosphere.

An example is the famous cold year of 1785, which followed the frightful eruptions of Mount Asama in Japan and Skaptar Jokull in Iceland. These produced a widely observed "dry fog " the phenomenon that led Benjamin Franklin to suspect a relationship between cold weather and volcanic eruptions.

Volcanic dust is believed to have played a role and perhaps a major one in the great climatic changes of past ages. Even relatively small variations in the Earth's annual mean temperature can cause widespread changes in Arctic ice packs and world sea levels, in desert boundaries, and in the geographic limits of plant, animal, and human life. According to Humphreys, volcanic dust blown into the stratosphere once a year or even once every 2 years, would continuously maintain temperatures low enough to cover the earth with a mantle of snow so extensive as to be self perpetuating, and thereby initiate at least a cool period, or, under the most favorable conditions, even an ice age.

The New England farmer of 1816, of course, knew nothing of such theories, he knew only that something had gone wrong with the weather. And when that dreadful summer was followed by a winter so severe that the mercury froze in the thermometers, he must surely have thought the change was permanent.

Extracts from History of Madison County, New York... "Town of De Ruyter, Madison County, New York.

In 1816 came the "cold season". There was frost in every month. The crops were cut off and the meager harvest of grain was nowhere near sufficient for the needs of the people. The whole of the newly settled interior of New York was also suffering from the same cause. The inhabitants saw famine approaching. (The alarm and depression so wrought upon the community, that a religious revival ensued.) What little grain there was that could be purchased at all was held at remarkable prices and this scant supply soon failed. Jonathan Bently at one time paid two dollars for a bushel of corn, which when ground proved so poor that it was unfit for use: throwing it to his swine, they to refused the vile food. Every resource for sustenance was carefully husbanded; even forest berries and roots were preserved. The spring of 1817 developed the worst phases of want. In various sections of the county, families were brought to the very verge of starvation! One relates that he was obliged to dig up the potatoes he had planted, to furnish one meal a day to his famishing family. Another states that his family lived for months without bread, save what was obtained in small crusts for his sick mother, and the milk was their chief sustenance. When the planting season arrived there was no seed grain in De Rutyer, so the inhabitants combined and sent Jeremiah Gage to Onondaga County to canvass for wheat and corn. He was absent several days and the people, all alive to the importance of his mission, grew discouraged, fearing that there was none to be found. At length he was seen approaching along the road, his wagon loaded. a crowd quickly gathered; there was great rejoicing and tears stood in strong mens eyes. Each family repaired to Gage's house to receive their quota of grain and every household that day was glad.